PROPOSED BLACKLOCK RESTORATION PROJECT

Suisun Marsh, Solano County, California
SRCD Ownership #635

Prepared By
Division of Environmental Services
California Department of Water Resources

in cooperation with
U.S Bureau of Reclamation
California Department of Fish and Game
U.S. Fish and Wildlife Service
Suisun Resource Conservation District

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DRAFT RESTORATION PLAN
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List of Acronyms

ADCP	Acoustic Doppler current profiler
BCDC	San Francisco Bay Conservation and Development Commission
BLL	Blacklock water quality monitoring station
BMPs	Best management practices
CBDA	California Bay Delta Authority
CCR	California clapper rail
CDEC	California Data Exchange Center
DEM:	Digital elevation model
DFG	California Department of Fish and Game
DWR	Department of Water Resources
EC	Electrical conductivity
ECAT	Environmental Coordination and Advisory Team
FWS	U.S. Fish and Wildlife Service
HDPE	High density polyethylene
MHHW	Mean higher high water
MLLW	Mean lower low water
MSL	Mean sea level
NAVD 88	North American Vertical Datum of 1988
NOAA	National Oceanic and Atmospheric Administration
NOS/COOPS	National Oceanographic and Atmospheric Administration's Ocean Service/Center for Operational Oceanographic Products and Services
OBS	Optical backscatter
PRBO	Point Reyes Bird Observatory
RWQCB	Regional Water Quality Control Board
SCMAD	Solano County Mosquito Abatement District
SET	Sediment erosion table
SMHM	Salt marsh harvest mouse
SMPA	Suisun Marsh Preservation Agreement
SRCD	Suisun Resource Conservation District
SSC	Suspended sediment concentration
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geographical Survey

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1.0 INTRODUCTION

The Department of Water Resources (DWR), in cooperation with the California Department of Fish and Game (DFG), U.S. Bureau of Reclamation (USBR), U.S. Fish and Wildlife Service (FWS), and the Suisun Resource Conservation District (SRCD), has prepared this Restoration Plan for the Blacklock site (Figure 1). This plan describes actions to restore 70 acres of diked, managed marsh to tidal wetlands, using a minimally engineered approach. The project goals and objectives are to 1) restore the area to a fully functioning, self-sustaining marsh ecosystem created through restoration of natural hydrologic, sedimentation and biological processes; 2) increase the area and contiguity of emergent wetlands providing habitat for tidal marsh species; and 3) assist in the recovery of at-risk species.

1.1 Background

DWR received CALFED Ecosystem Restoration Program grant funds in 2001 and acquired this property in December 2003. NEPA/CEQA compliance for the acquisition of this property was completed when DWR filed a Notice of Exemption in May 2003 and the USBR published a FONSI Federal Register in November 2003.

This property is identified as SRCD ownership number 635. The grant proposal, *Suisun Marsh Property Acquisition and Habitat Restoration Project*, was prepared and submitted by DWR in 2000 with collaboration from the Suisun Marsh Preservation Agreement (SMPA) Environmental Coordination and Advisory Team (ECAT), which includes DWR, USBR, DFG, SRCD, and USFWS. Since Suisun Marsh Mitigation Agreement Funding was identified as the source of cost-share funding for this effort, this became an ECAT project.

The original proposal identified that Phase I (acquisition and pre project monitoring) and Phase II (restoration plan development) would be completed with the available funds. Although it was anticipated that additional funding would be required to complete Phase III (environmental documentation and permitting), Phase IV (Implementation of the plan) and Phase V (monitoring). It appears that existing funding will be available to fund the project through implementation. Once this Blacklock Restoration Plan is approved, DWR and the SMPA ECAT agencies will seek additional funding for Phase V.

The plan is organized into the following sections:

Section 1: Introduction and Background

Section 2: Site Description

Section 3: Existing Site Conditions

Section 4: Description of Proposed Project and Alternatives

Section 5: Monitoring

Section 6: Final Design and Implementation Activities

Section 7: References

1.2 Goals and Objectives

The goals and objectives guiding this project are as follows:

Goals: To increase the area of tidal brackish emergent wetlands in Suisun Marsh to aid in the recovery of listed and sensitive species, and (2) acquire scientific knowledge that leads to improved understanding of tidal marsh restoration processes, strategies, and ecological outcomes within Suisun Marsh.

Restoration objectives: To restore the Blacklock property to a self-sustaining functioning brackish tidal marsh by restoring tidal action, reversing subsidence, and promoting establishment of native vegetation and a tidal marsh channel network appropriate to this location within the San Francisco Estuary.

Science objectives: To allow for and encourage collaborative science opportunities in the project design and monitoring phases that supports regional adaptive resource management needs.

1.3 Anticipated Outcomes

Projected outcome scenarios are based on a variety of sources, use of computer models, and review of the literature and evaluation of other restorations within the San Francisco Estuary.

- The site would increase in elevation over time via natural sedimentation processes-mineral sediments moving in from Little Honker Bay and decomposition of vegetation on site.
- Full, unimpeded tidal exchange throughout the site.
- As elevations increase, vegetation will colonize throughout the site.

This restoration represents an opportunity to realize many of the ecosystem benefits that are commonly associated with healthy tidal marsh habitat. Fisheries benefits include providing habitat for delta smelt (*Hypomesus transpacificus*), longfin smelt (*Spirinchus thaleichthys*) Sacramento splittail (*Pogonichthys macrolepidotus*), chinook salmon *(Oncorhynchus tshawytscha)* and other aquatic species. Targeted wildlife species include Suisun song sparrow (*Melospiza melodia maxillaris*), marsh wren (*Cistothorus palustris*), black rail (*Laterallus jamaicensis*), common yellowthroat (*Geothlypis trichas*) and other avian species.

Restoration of tidal flows will produce substantial changes to the habitats and biological, physical, and chemical functions of the site. Immediately after breaching, the site is expected to be shallow open water with remnant emergent vegetation (Figure 2) during much of the tidal cycle and exposed pond bottom and remnant vegetation during low tides.

A new tidal channel network is expected to form, partially re-occupying remnant channels and otherwise forming within the newly forming tidal marsh surface. Vegetation will transition to a mix of species suited to the intertidal brackish environment, with the site eventually becoming fully vegetated except for channels. Some open water areas may persist in the long term.

Knowledge expected to be gained from this restoration includes but is not limited to rates of sedimentation and marsh development, the role of existing emergent vegetation in influencing sedimentation, channel network formation and overall geomorphology, hydrology, water quality impacts, methyl mercury production, and species use. Results will inform scientists and decision makers in long-term land use and restoration planning throughout Suisun Marsh.

1.4 Organizational Structure

Because of the collaborative structure of ECAT, there are several agencies involved in this planning effort. The Project Work Team (Appendix A) is comprised of those participating in a hands-on effort on this project. While DWR is doing the majority of the data collection and project management, other agencies, institutions and individuals are represented on this team. The Advisory Team (Appendix B) is comprised of staffs from each ECAT agency and others who are providing technical expertise and agency review on the project. The role of the Advisory Team is to review materials developed by the Project Work Team and make recommendations to the SMPA Coordinators, identified as the decision makers. The SMPA Coordinators are an established group comprised of managers from each SMPA agency (DWR, DFG, USBR, SRCD). Staff at DWR, Division of Environmental Services is responsible for Project Management for the Blacklock Restoration Project.

Comments from reviewers during the grant selection and approval process suggested that the team needed to include independent, qualified individuals with expertise in tidal marsh restoration in the region. DWR contracted with Leonard Sklar, Professor of GeoSciences at San Francisco State University to collect sediment transport data in support of restoration plan development. Point Reyes Bird Observatory (PRBO) Conservation Science conducted avian monitoring of the site. Stuart Siegel, Principal of Wetlands and Water Resources was identified as the Science Advisor on this project. In an advisory role, Dr. Siegel has assisted in project development, review of sediment transport data, hydrologic conditions, geomorphology and other data collected in support of restoration plan development.

1.5 Regulatory Jurisdiction

The San Francisco Bay Conservation and Development Commission (BCDC) has jurisdiction over the area as part of the Suisun Marsh Preservation Act. Because this parcel (with the exception of some of the levees) is jurisdictional wetland, the U.S. Army Corps of Engineers (USACE) authorizes work activities under the Section 404 of the Clean Water Act. The Regional Water Quality Control Board (RWQCB) certifies the water quality components under Section 401 of the Clean water Act.

All routine maintenance is authorized under the regional maintenance permit issued by the USACE to the SRCD and DFG.

DWR is the CEQA lead and USBR is the NEPA lead on this project.

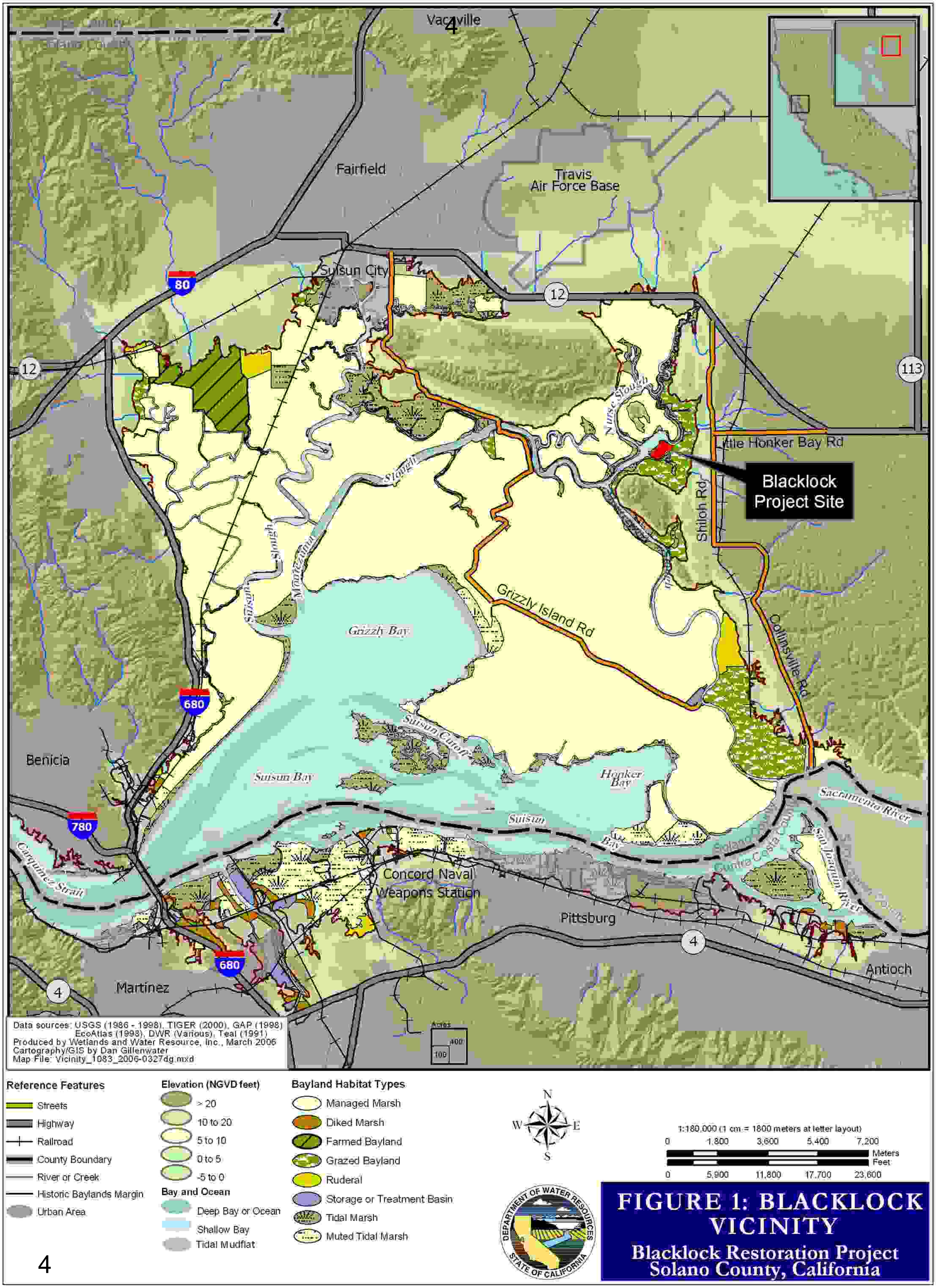


FIGURE 1: BLACKLOCK VICINITY

Blacklock Restoration Project
Solano County, California

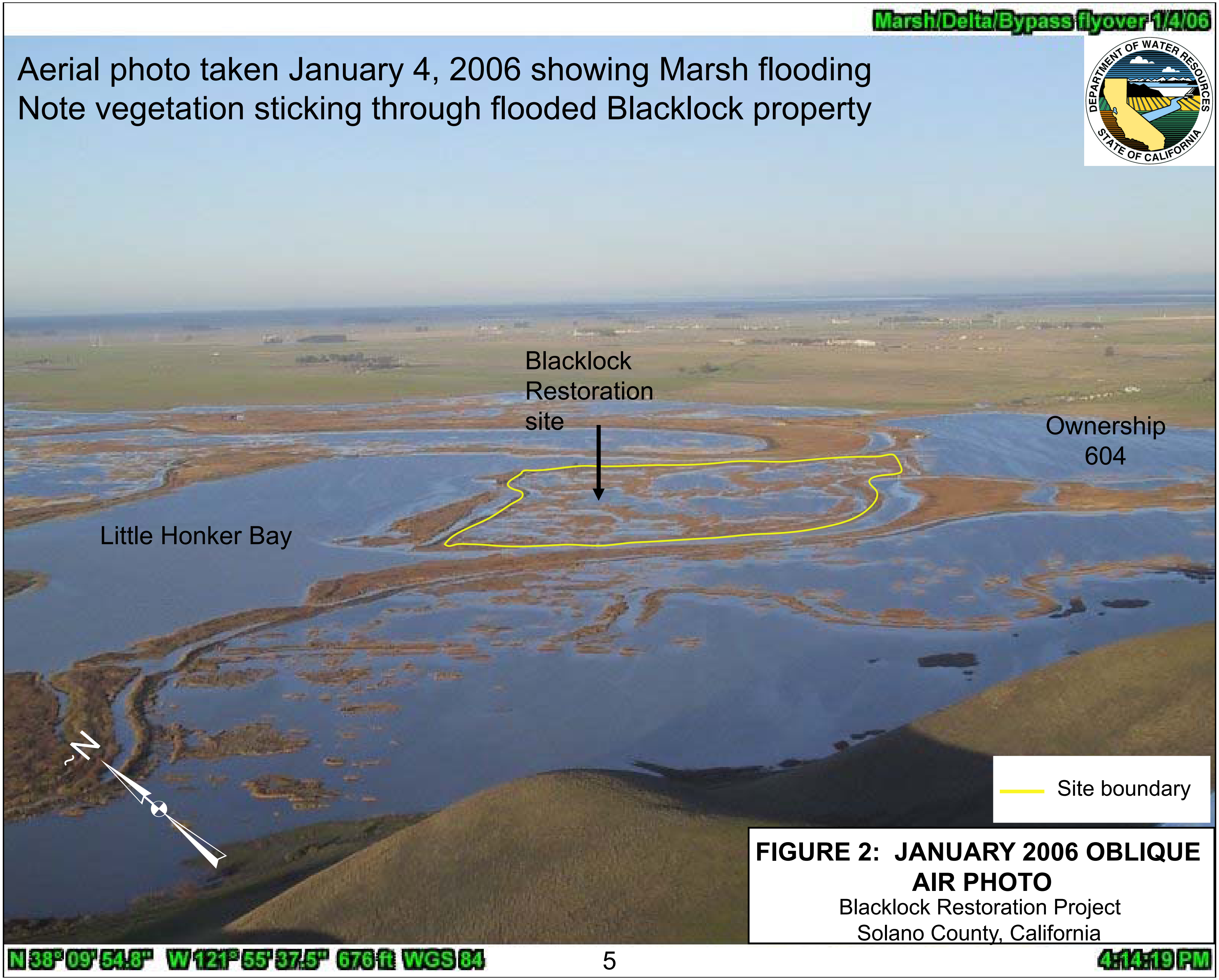


FIGURE 2: JANUARY 2006 OBLIQUE AIR PHOTO
Blacklock Restoration Project
Solano County, California

2.0 SITE DESCRIPTION AND HISTORY

2.1 Location and Physical Features

The Blacklock site is located in the northeast Suisun Marsh bordering Little Honker Bay (Figure 1). The parcel is approximately 70 acres, which includes about 67 acres seasonal wetland and 3 acres upland/levee. Existing site features include a diked, managed marsh, a partial remnant network of sloughs, an interior borrow ditch, and seasonally and perennially ponded areas (Figure 3). There is fringing tidal marsh on the outboard side of the exterior levees.

2.2 Adjacent Properties

The proposed restoration site is bordered by one adjacent property located to the east and separated by a 1,100-foot long levee, which serves as the property line. Three bodies of water identified as Little Honker Bay, Denverton Slough/Little Honker Slough, and Arnold Slough border the remainder of the site to the west, north, and south, respectively. The one adjacent property, marsh ownership 604, is owned by William L. Blacklock and is used for duck hunting and livestock grazing activities.

The adjacent property contains a diked marsh, primarily vegetated with pickleweed (*Salicornia virginica*), grading to a large expanse of upland grassland. The two properties are separated by a levee that was elevated in 2004 to minimize the possibility of overtopping of waters onto the adjacent property.

2.3 Site History and Land Use

The Blacklock restoration site has been owned and operated by the Blacklock family since 1936, and has been used for livestock grazing and duck hunting activities since 1946 (DWR 2003). The past owner used the entire Blacklock Ranch property primarily for grazing, with some waterfowl hunting in the southwest portion of the Blacklock Ranch including the 70 acres acquired by DWR. Management on the wetland area was minimal, consisting primarily of flooding and circulation during duck hunting season.

The SRCD has developed 11 water management schedule guidelines to assist wetland property owners and managers. The goal of these water management schedules is to optimize the waterfowl forage and cover value. Selection of the appropriate water management schedule is based on location in the Marsh, water control facilities, and water type. Location of a club will determine whether or not its management is affected by endangered species closures. Clubs affected by endangered species closures must restrict or close water intake structures during specific periods to prevent adverse impacts to Chinook salmon and/or delta smelt.

Past club management on the site was variable and did not strictly adhere to any of SRCD's water management schedules. According to Mr. Blacklock, initial flooding of the ponds started in early to mid-October. Ponds were flooded to a maximum depth of 12". Water levels remained static through mid-December at which time the water level was lowered slightly to make invertebrates more easily accessible to feeding waterfowl. Intakes were closed from February 21st through March 31st due to salmon closure requirements. The pond was drained by mid- to late-June and allowed to dry out for cattle grazing. Based on the existing topography and interviews with the owner, disking, ditching and burning on the property were minimal.

Levee maintenance appears to have been minimal and inadequate to protect the property from occasional tidal overtopping. The levees were maintained primarily by borrowing material from the interior toe ditch. It appears that rip-rap was periodically imported to maintain a portion of the exterior levee along little Honker Bay.

2.4 Interim Management

DWR, with cooperation from SRCD, developed an Interim Management Plan for the property in January 2004. This plan, which identifies several potential management goals proposed for the site, was reviewed and approved by the SMPA Coordinators. An underlying premise of the strategies described in the plan is that during the interim management period, land use at the site will continue to be a seasonal wetland and each of these management goals must be achieved utilizing existing strategies for seasonal wetland management. This plan is available on-line at http://iep.water.ca.gov/suisun/restoration/blacklock/doc/Blacklock.

Upon careful review of the plan, the Advisory Team recommended, and the SMPA Coordinators supported, the interim management strategy to prepare the site for restoration. This management strategy described how to maintain managed wetland in a manner that will not conflict with, and will work towards, the long-term goals of tidal marsh restoration. This management strategy would be achieved by implementing actions that increase vegetation cover at the site prior to breaching. As described in the plan, actions could also incorporate studies evaluating methods for subsidence reversal and, where necessary, substrate modification.

As described in the plan, interim management would include moderate water control manipulation, moderate vegetation control and an investigation of techniques for subsidence control and substrate modification. The plan identified advantages of this strategy to include: 1) consistency with the long-term goal of tidal marsh recovery, and 2) creation of physical conditions conducive to tidal marsh evolution. This strategy was also seen as a way to inform the larger California Bay Delta Authority (CBDA) goals for tidal wetland restoration in Suisun Marsh.

In implementing this strategy, DWR has been manipulating water on the site through the existing 36-inch culvert to encourage the growth of emergent vegetation and allow for circulation throughout the property. In late summer of both 2004 and 2005, the pond was drained (to the extent possible) to allow for construction work on the cross levee (described in section 3.3.1). Once levee construction was completed, the property was re-flooded to previous levels.

FIGURE 3: 2004 AERIAL PHOTO

Blacklock Restoration Project
Solano County, California

3.0 EXISTING SITE CONDITIONS

3.1 Physical Features

3.1.1 Topography

The Department of Water Resources conducted a field elevation survey of the site in August 2002. Figure 4 shows the digital elevation model (DEM) created by DWR and updated by WWR using the topographic data. Elevations at the site range from approximately -1.9 feet up to 9.2 feet (NAVD 88). With the exception of the levees and the two well sites, most of the property is subsided, with elevations less than about 3 feet and less than about 1 foot on most of the site. The mean sea level at this location is approximately 4 feet. Additional elevation surveys were conducted on the perimeter borrow ditch and slough network during 2005.

3.1.2 Soils

The U.S. Department of Agriculture soil survey for Solano County (USDA 1975) shows only two soil types at the Site. The area inside the levee is Tamba Mucky Clay, and Tidal Marsh soils are present outside the levees.

The Tamba soil series consists of very poorly drained, fine-textured soils with a high organic matter component. The soils occupy nearly level salt and brackish water marshes and are formed in mixed alluvium from mixed sources and hydrophytic plant remains. In a typical profile, the mucky clay extends to a depth of more than five feet.

This very poorly drained soil is moderately permeable. The surface runoff is ponded and the erosion hazard is slight to none. The total available water holding capacity is 3-5 inches. The effective rooting depth is shallow and the soil has low fertility. Areas with this type of soil association are typically used for wildlife habitat, recreation (irrigated duck ponds) and grazing.

The tidal marsh soil is a very wet, poorly drained, and strongly saline soil type that has unobstructed access to tidal water. This land ranges from unvegetated mud flats that are inundated daily by tidal flow to a mixture of hydrophytic plant remains and alluvium that is covered by water only at high tide and are (at this site) thickly vegetated with *Schoenoplectus Bolboschoenus* and *Typha*. Permeability and runoff rates are low with these soils. Effective rooting depth is very shallow and fertility is very low. This land type is used for wildlife habitat and recreational uses. (US Department of Agriculture, 1975)

3.1.3 Hydrology

Because of the location and relative isolation of the parcel, there are no watershed inflows that would affect the hydrology of the site except under extreme tidal/flooding scenarios as occurred in 1998, 2005 and 2006. Tidal inundation, as described below, along with site elevation, has the greatest influence on the development of a fully functioning tidal marsh.

The Blacklock parcel has been flooded since late December 2005. Weather and Delta outflows during winter 2006 resulted in higher than normal tides throughout Suisun Marsh, sometimes 1-2 feet above predicted levels. The flooding is due to overtopping of the levees at high tides and seepage through the levee in several locations.

As a managed wetland, the hydrology of the site is primarily controlled by one 36-inch water control structure located along Arnold Slough (Figure 5); however, uncontrolled intermittent levee overtopping such that occurred during winter 2006 also impacts water levels.

Water Control

There is one water control structure for both flooding and draining the property. The structure consists of a 36-inch corrugated metal pipe with a screw-flap gate on the slough side and a winch flap gate on the interior side. The gate was installed in the summer of 1998 and is in good working order. There is also a 48-inch pipe under the road to the well pad to allow circulation in the borrow ditch that runs along the interior toe of the levees. This culvert under the road was replaced with high density polyethylene (HDPE) pipe in August 2005. A flashboard riser was installed on the west side of the pipe, and will be closed upon breaching of the levee to reduce circulation in the perimeter borrow ditch.

Tidal Datum Reckoning

DWR contracted with the National Oceanographic and Atmospheric Administration's Ocean Service / Center for Operational Oceanographic Products and Services (NOS/CO-OPS) to install a water level observation gauge on Bradmoor Island in 2004 where it had previously operated a station in the 1970's (Station ID NOS 941-4811). The purpose of the gauge is to determine the tidal datum (heights and range of the tides) for the Nurse Slough/Denverton Slough complex in the northeast Marsh, in the vicinity of the Blacklock property. The project included installation of two geodetic benchmarks to augment three existing benchmarks.

NOS/COOPS will use these data to update tidal datum and tide predictions for this station. NOS/COOPS agreed to install and operate the tide gauge for a minimum of one-year and to use recently developed tidal datum calculation standards (NOAA 2003) to update the tidal datum at the Bradmoor station site. Five benchmarks are required to meet survey standards; three historical benchmarks currently exist at the site. Elevations of all five benchmarks were checked during water level instrument installation (April 2004), and after 6-months. NOAA removed the gauge in April 2006.

NOS/COOPS processed the data and computed a preliminary 4-month (April through July, 2004) tidal datum (Table 1). Several height statistics are represented including mean higher high water (MHHW), mean sea level (MSL), and mean lower low water (MLLW). All heights are referenced to the North American Vertical Datum of 1988 (NAVD 88). NOS/COOPS will provide a final report on the tidal datum elevations and the geodetic datum relationships to DWR when available. All preliminary and verified data obtained from the Bradmoor station is available on a real-time basis via the NOS website at http://tidesonline.nos.noaa.gov/.

A water quality monitoring station was installed at the northeast corner of the Blacklock property (Figure 5). This station monitors tide stage, electrical conductivity (EC) and temperature in Denverton /Little Honker Slough. The station also monitors precipitation, wind speed and direction. In addition, a pressure transducer was installed in the borrow ditch of the Blacklock property to monitor interior water levels. After breaching, this sensor will provide data on the extent of tidal inundation. This station is identified as BLL on the California Data Exchange Center (CDEC) network. Hourly data is available on-line at http://cdec2.water.ca.gov/cgi-progs/queryFx?s=bll.

When the full-year report is available, DWR will produce an analysis of the difference between Bradmoor and Blacklock tidal datums. Preliminarily, the stage signal between Bradmoor and Blacklock is very similar as shown on Table 1. Stage at the Blacklock gage is tending to be a few centimeters higher than Bradmoor at high tide.

Table 1 - Tidal Datum Diagram of Bradmoor Island Tides

NAVD88 Tidal Datum Diagram for Bradmoor Island Tides

	Meters	Feet
Gas well BM on Blacklock concrete pad	2.350	7.71
MHHW	1.956	6.418
MHW	1.797	5.896
* PBM 4811 C 1978	1.766	
MSL	1.170	3.834
MTL	1.154	3.786
MLW	0.511	1.677
MLLW	0.283	0.929

Preliminary Bradmoor Is. Tidal Datum

Preliminary data based on 4 months of data collected from April - July 2004
* Primary Bradmoor Bench Mark
Gas well BM tied to GPS network station BR2 near Mr. Blacklock's dock (7.01 ft NAVD88). GPS elevation of Gas well resurveyed in 2005 by WWR.

Existing Slough Network

There are remnants of the historic tidal marsh slough network on the site (see Figure 3). DWR surveyed slough topography as part of its August 2002 survey. To supplement the original survey, additional surveys of the slough bottoms were conducted in March 2005. These remnant sloughs range in width from 5 to 15 feet and in depth from ½ to 2 feet across the site. In addition, there is a perimeter borrow ditch around the property along the interior toe of the exterior levee. Over the years, material has been removed from this ditch and used to maintain the levees. An elevation survey of this ditch was conducted in 2005. The width of the borrow ditch varies from approximately 10 feet to 35 feet wide and extends into ponded areas at several locations throughout the parcel.

3.1.4 Suspended Sediment Concentration

Methods

In-situ suspended sediment sampling was carried out at two locations outside the Blacklock site at Little Honker Bay and Arnold's Slough (Figure 5). Little Honker Bay, west of the Department of Water Resources Blacklock property, is a small open water body. Arnold Slough, south of the Blacklock property is a narrow slough channel. At each location, a D&A Instruments OBS-3 sensor connected to an OWL2c data logger was mounted 0.9 feet above the substrate. Approximately every two weeks the OBS sensor was cleaned, data from the datalogger downloaded, and batteries exchanged. The sensor at Arnold Slough was deployed from December 21, 2004 to January 4, 2006. The Little Honker Bay sensor was deployed December 21, 2006 and is presently still collecting data.

OBS readings were taken once every 12 minutes (or 15 minutes for a few deployments) to correspond with the NOS tidal gauge at the nearby Bradmoor Island station. Each sample burst consisted of 64 samples at 0.1Hz. The data logger recorded date, time, battery voltage, and OBS minimum, maximum, average, and standard deviation.

The OBS sensors were calibrated in the field using four different concentrations of field sediment/water samples. The actual sediment concentration of the calibration samples was analyzed in the laboratory using the ASTM standard D 3977 – 97, "Standard Test Methods for Determining Sediment Concentration in Water Samples". "Method B-Filtration" was used for all samples collected.

Data was filtered for a number of factors that were thought to cause unsound data. First, errant data due to the logger taking readings when the sensor was out of the water for maintenance at the start and end of each deployment were filtered. Second, records portraying a low battery status (less than 9.7v) were filtered out. Third, data was filtered out each time the water surface was within 1.0 feet of the sensor head (as determined by the NOS Bradmoor Island tidal records) as the OBS sensor reports errant readings from ambient light. Lastly, to remove data flyers, a difference from the running mean (one hour before and after) was calculated and any data with greater than a 20 percent difference was filtered out.

Due to the combination of sediment and algae collecting on the optical surfaces of the OBS sensors, data drift was apparent and corrected for using fitted curves based on the difference in readings pre- and post-cleaning.

<u>Results</u>
Suspended sediment concentration (SSC, milligrams per liter or mg/L) results are shown in Figure 6. Results are shown separately for Little Honker Bay and Arnold Slough, and the difference in magnitude of the 2-hour running mean between the two stations is also shown in order to illustrate differences between the two locations.

At Little Honker Bay, concentrations ranged from a low of about 20 mg/L to nearly 500 mg/L, with most values being less than 200 mg/L. Data shows a small spring-neap tide cycle signal. SSC tended to be higher in the winter and spring months and lowest in the fall months. At Arnold Slough, concentrations ranged from a low of about 30 mg/L to a high of about 430 mg/L, with most values being less than 150 mg/L. Arnold Slough shows the same seasonal pattern observed at Little Honker Bay.

The SSC difference between the two stations shows greater SSC values at Little Honker Bayduring winter, spring and summer months, with the difference ranging from 10-30 mg/L commonly and in some instances up to 200 mg/L. Values were higher at Arnold Slough during the fall, by about 10-20 mg/L typically.

These results provide two beneficial pieces of information. First, they indicate that a reasonable sediment supply exists to support natural sedimentation within the Blacklock site. The values observed are within commonly seen ranges elsewhere in the San Francisco Estuary where natural sedimentation is known to occur in tidal marsh restoration sites (PWA and Faber 2004). Second, these data can support sediment transport modeling that DWR may undertake after project construction to develop more insight into physical processes promoting tidal marsh restoration in Suisun.

3.2 Existing Biological Conditions

3.2.1 Regional Biology

The regional biology of the Suisun Marsh is described in general in the Bayland Habitat Goals Report (1999) and the final report prepared in 2001 by the Suisun Ecological Workgroup at the request of the State Water Resources Control Board. This report can be found on line at http://www.iep.ca.gov/suisun_eco_workgroup/final_report/SEWFinalReport.pdf. Most of the Suisun Marsh is diked seasonal wetlands managed for waterfowl habitat. A few tidal marshes remain along Suisun and Cutoff Sloughs (Rush Ranch), Hill Slough, and Peytonia Slough. Marsh ponds exist to a limited extent in low areas of diked baylands.

3.2.2 Ecosystem Types

The site is characterized by 3 main ecosystem types: upland, seasonal wetland, and aquatic. The upland areas of the site are restricted to the levees and the abandoned well pad. The sloughs and pond areas comprise the aquatic areas of the site; over the past several years, water has remained in the central portion of the site year-round. The majority of the site is managed seasonal wetland. The distribution of vegetation present is primarily a function of the topography on the site and inundation due to water management.

3.2.3 Special Status Species

A list of sensitive species of wildlife and plants that are known to occur in the vicinity of the Blacklock Restoration site is provided in Appendix C. No special status species of plants have been observed within the project boundaries but several including Masons liliaopsis (*Liliaeopsis masonii*), Suisun Marsh aster (*Aster lentus*), Suisun thistle (*Cirsium hydrophilum var hydrophilum*), Delta tule pea (*Lathyrus jepsonii var jepsonii*), soft bird's-beak (*Cordylanthus mollis mollis*) and Contra Costa goldfields (*Lasthenia conjuguens*) are found in the Suisun Marsh.

With the exception of the State and federally listed salt marsh harvest mouse (*Reithrodontomys raviventris halicoetes*), and Suisun song sparrow (*Melospiza melodia maxillareies*), no sensitive wildlife species have been observed within the project area. The results of SMHM surveys are described below in section 3.2.7. Bird surveys are described in Section 3.2.6 below. Surveys for California black rail (*Laterallus jamaicensis coturniculus*) are ongoing.

3.2.4 Vegetation

The Department of Fish and Game, Wildlife Habitat Division conducted a comprehensive vegetation survey of Suisun Marsh in 1999. Change detection surveys were conducted in 2000 and 2003. Figure 7 shows the Blacklock portion of the resulting vegetation map representing conditions in June 2003. Vegetation in the wetland consists primarily of tules (*Shoenoplectus acutus*), cattails (*Typha*) and saltgrass (*Distichlis spicata*), with some waterfowl food plants such as brass buttons (*Cotula coronopifolia*) and alkali bulrush *(Bolboschoenus maritimus)*. Vegetation along the levee includes native rose (*Rosa californica*), blackberry (*Rubus discolor*), and annual grasses. With the site inundated since January 2006, only emergent vegetation is visible; salt grass and pickleweed is submerged.

3.2.5 Aquatic Species

Three locations (Figure 8) were beach seined on August 25, 2004 to evaluate pre-project fish presence and diversity. At the sites seined, water depth varied from 0.3 to 3.0 feet. Seining was done days before the culvert was re-opened following the end of the Chinook salmon closure period. Three locations were chosen for sampling according to a likelihood of catch and for their accessibility. A beach seine was used to span the channel and corral fishes present to the bank where individuals were placed into a holding bucket for identification.

Native and introduced species were captured at all three locations. Native fishes caught include tule perch (*Hysterocarpus traskii traskii),* prickly sculpin (*Cottus asper*), three-spine stickleback (*Gasterosteus aculeatus)* and Sacramento blackfish (*Orthodon microlepidotus*). Black crappie (*Pomoxis negromaculatus)*, Shimofuri gobi (*Tridentiger bifasciatus*), inland silversides (*Menida beryllina*), mosquito fish (*Gambusia affinis*), brown bullhead (*Ictalurus nebulosus*), carp (*Cyprinus carpio*) and American shad (*Alosa sapidissima*)comprise the introduced species sampled. Temperature, D.O. and E.C. were recorded prior to seining for each site. Numerous *Palaeomon* shrimp, crayfish and other invertebrates were also observed. Table 2 shows the results of the 2004 survey.

Table 2 - Fisheries sampling results

Native Species		Sampling locations as shown on Figure 8
Tule perch	*Hysterocarpus traski*	3
Prickly sculpin	*Cottus asper*	1,2
Three-spine stickleback	*Gasterosteus aculeatus*	1
Sacramento blackfish	*Orthodon microlepidotus*	3
Introduced Species		
Black crappie	*Pomoxis nigromaculatus*	1,2,3
Shimofuri gobi	*Tridentiger bifasciatus*	1,2
Inland silverside	*Menidia beryllina*	2,3
Mosquito fish	*Gambusia affinis*	1,2,3
Brown bullhead or Black bullhead	*Ameiurus nebulosus* *Ameiurus melas*	3
Carp	*Cyprinus carpio*	2
American shad		3
Invertebrates		
shrimp	*Palaeomon*	1,3
Crayfish		3
Others		1,2,3

From DWR fisheries sampling August 25, 2004
1) borrow ditch on SE side of property, and NE side of well road culvert near diversion intake structure
2) first-order slough from borrow ditch (south of well pad) to 20 feet interior;
3) borrow ditch at NE corner of site from corner to 25 feet to the SW.

3.2.6 Birds

PRBO Conservation Science (PRBO) biologists conducted a variety of surveys at the Blacklock restoration site, periodically through the annual cycle, from spring 2004 to spring 2005. In addition, PRBO conducted avian surveys at additional sites in the vicinity of the Blacklock site. Surveys were conducted at two nearby sites: a managed, seasonal marsh located on the Delta King Ranch and a fringing tidal marsh on the Overlook property neighboring Blacklock ranch (Figure 8). The Overlook site was intended to serve in part as a "reference" site, indicative of the future tidal marsh habitat to be developed as a result of the Blacklock restoration project. A fourth site, Rush Ranch, was surveyed in spring 2004 and spring 2005; this site was chosen as a good example of the target tidal marsh habitat in a site that is more comparable in size and configuration to the Blacklock site and therefore can serve as a good reference site.

Objectives of the project addressed by this study include:

- What are the impacts to avian species of converting seasonal, managed wetlands to tidal marsh? Which species can be expected to be more prevalent and which species less prevalent as a result of this habitat change?
- How does the pattern of habitat use (e.g., seasonally) by birds change as a result of habitat change?
- What are the characteristics of restored tidal marsh habitat and the surrounding landscape, as applied to Suisun Marsh, that maximize its wildlife value to birds?

To address these questions, variable-distance point count surveys were conducted once a season (fall, winter) or twice a season (early spring, late spring; no surveys during summer) at each site. This type of survey provides an index of abundance for each species and information on species composition, covering all avian species and is the survey method best suited for passerines and other "landbirds." A second type of survey, area surveys (also termed "line-transect surveys") was carried out at the less vegetated Delta King and Blacklock sites. This type of survey provides an index of bird abundance and provides information on non-passerines such as waterfowl, shorebirds, and herons and egrets (though these groups are also surveyed by point counts). The behavior and micro-habitat utilization of the birds was also recorded with area surveys.

Survey locations at Blacklock are shown on Figure 8. California Black Rails (*Laterallus jamaicensis coturniculus*) were surveyed in the spring of 2005 at the three Blacklock-vicinity sites; these species-specific surveys are conducted twice during the breeding season. This state-threatened subspecies is highly secretive but very vocal, especially when taped calls are played back. A fourth survey, specifically for California clapper rails (CCR) (*Rallus longirostris obsoletus*) was conducted in the area surrounding Rush Ranch. CCR surveys were not not conducted in the vicinity of Blacklock because the property in not in within the critical habitat of this species. Marshwide surveys for CCR do not extend this far east. Protocols for all surveys used were consistent with those developed as part of the San Francisco Estuary Wetlands Regional Monitoring Program (San Francisco Estuary Wetlands Regional Monitoring Program 2002; www.wrmp.org).

Species richness was moderately high at the Blacklock site with 27 different species present at the site including Suisun song sparrow (*Melospiza melodia maxillaris*), marsh wren (*Cistothorus palustris*), and common yellowthroat (*Geothlypis trichas*). These three species or subspecies are mainly dependent on tidal-marsh habitat, though they may also use habitat with limited tidal flow, provided the appropriate vegetation is present. During the breeding season, bird use at the Blacklock site was limited: only 12 species were detected. In contrast, the Overlook site displayed higher species richness throughout the year (33 species detected) and specifically during the breeding season (16 species detected). The Rush Ranch site, where surveys were conducted during the breeding season only, demonstrated 15 species.

One difference between the Blacklock pre-restoration site and the two tidal marsh sites (Overlook and Rush Ranch) is the higher abundance of common yellowthroats and Black Rails at the tidal marsh sites, especially at Rush Ranch. For example, Black Rail Surveys at Rush Ranch in 2001 (the last year conducted there) revealed detections of this species at 6 out of 10 survey stations. At the Blacklock site, there were detections at only 2 of the 10 survey stations. Similarly, common yellowthroats displayed high abundance at Rush Ranch, almost equal to that of marsh wrens, whereas this was not the case at the Blacklock site. Studies conducted in San Pablo Bay and Suisun Bay by PRBO biologists demonstrated that common yellowthroats are present at marshes of all ages but that their abundance increases with marsh age, thus, on average, ancient tidal marshes displayed the highest density and young restoration sites the lowest density (Nur et al. 2004)

In addition, the study demonstrated the value of managed marsh as bird habitat. The Delta King site demonstrated a species richness of 48 species over the course of 1 year and 29 species detected during the breeding season, values that are about twice that observed at the Blacklock site and also substantially greater than at the tidal marsh sites. Dabbling ducks are one species group that benefits from managed marsh habitat, and to an extent, piscivorous birds do as well (such as gulls, terns, herons, and egrets).

Many tidal marsh-dependent species are year-round residents. For them, the chief value of tidal marsh habitat is as breeding habitat. Such species include song sparrows, common yellowthroats, marsh wrens, and black rails. There are a few waterbird species that also utilize tidal marsh habitat for breeding, for example, snowy egrets (*Egretta thula*) which were detected at Overlook site during the breeding season. However, for most waterbirds species, the chief value of tidal marsh habitat, and also managed marsh habitat, is for foraging and roosting during the migratory periods (fall and spring) and during the winter. Studies conducted at young restoration sites demonstrated the value of these sites for waterbirds during the fall and winter periods (Nur et al. 2004, Nur et al. 2005); this is especially so for shorebirds.

The results of this study, coupled with that of other studies conducted in San Francisco Estuary (Nur et al. 2004, Nur et al. 2005), suggest that a wide spectrum of birds will benefit from planned restoration projects. The value to birds will be greatest when the target sites are currently not managed or with a low level of management, as at Blacklock Ranch. Shorebirds will especially benefit from young restored marshes where channels and mudflats are present and vegetation of the marsh plain is not complete. However, dabbling ducks will be able to use young and mature marsh provided that foraging opportunities (e.g., channels) are present. Passerines, such as song sparrows and common yellowthroats, will benefit from tidal marsh habitat, though they are able to utilize pre-restoration habitat as well. Black rails, however, appear to be more dependent on mature tidal marsh.

At the same time, there is clearly great benefit to birds provided by intensively managed shallow-water habitat. Thus, restoration plans that call for a mosaic of habitat types, and thus a high heterogeneity of habitat types will be most beneficial to a wide range of bird species. Within a habitat, structural (including vegetational) heterogeneity should also be promoted. Tall vegetation favors some species (e.g., common yellowthroats) while dense, short vegetation favors others (e.g., black rails; Spautz et al. in press). Many species benefit from a developed system of channels and the vegetation (e.g., *Grindelia*) that is found along those channels.

3.2.7 Salt marsh harvest mouse

The salt marsh harvest mouse (SMHM, *Reithrodontomys raviventris*) is a federal and State endangered species endemic to the brackish and salt water marshes around the San Francisco Bay Estuary. There are two subspecies, and it is the northern subspecies, (*R.r. haliocetes*), that is found in the Suisun Marsh. DWR conducted SMHM surveys in 2003, 2004 and 2005. Each survey was done using Sherman live traps, which were opened for four consecutive nights.

In 2003 two areas of the pond were surveyed: Grid Pond 1 in the NE pond where vegetation is primarily salt grass (*Distichlis spicata*) and fat hen (*Atriplex triangularis*), and grids 2 and 2a in the SE pond near the well pad, which is primarily pickleweed (*Salicornia virginica*). A total of 105 traps were set, and SMHM were captured only in the area around the well pad.

In 2004, surveys were conducted in the two areas surveyed in 2003 (grids Pond 1, 2 and 2a) and five additional areas, including three areas along the exterior levee (Pond 3, 4, 4a and Levee 1, 2 and 3). A total of 108 traps were set for four consecutive nights. Vegetation at the levee sites was primarily *Schoenoplectus* and *Typha*, and except for the area near the well pad (Grids 2 and 2a), which was primarily pickleweed, the pond sites were primarily salt grass.

In 2005, six areas were surveyed: grids Pond 1, 2, 3, 5 and Levee 1 and 2. The only new area was Pond 5, located in the southwest corner of the pond in an area vegetated with tall emergents such as Typha and *Schoenoplectus*. Survey results are in Table 3 and the survey sites shown on Figure 8.

Because the pond was flooded during the winter of 2005/2006 and has remained flooded with 1-2 feet of water since then, all SMHM habitat within the pond is inundated.

Table 3 - SMHM Survey results by grid at Blacklock, 2003-2005

Grid	2003		2004		2005	
	# traps	Results[1]	# traps	Results	# traps	Results
Pond 1	30	1 WHM	20	3 UNHM, 2 WHM	15	1 WHM
Pond 2	53	7 SMHM	15	2 UNHM, 2 WHM	18	
Pond 2a	22	5 SMHM	7	1 WHM	N/A	
Pond 3	N/A		15	2 SMHM, 3 UNHM, 2 WHM	11	1 SMHM
Pond 4	N/A		8		N/A	
Pond 4a	N/A		10		N/A	
Pond 5	N/A		N/A		16	1 SMHM, 1 UNHM, 3 WHM
Levee 1	N/A		14	2 SMHM, 2 WHM	20	2 UNHM, 3 WHM
Levee 2	N/A		10	3 SMHM, 2 UNHM, 2 WHM	20	1 SMHM, 4 UNHM, 5 WHM
Levee 3	N/A		9	1 WHM	N/A	

1/ SMHM=salt marsh harvest mouse; UNHM=unknown harvest mouse, morphological characters between those of SMHM and WHM; WHM=western harvest mouse, *Reithrodontomys megalotis*.

3.3 Historical and Cultural Resources

A search of the records maintained at the Northwest Information Center of the California Historical Resources Information System at Sonoma State University did not identify any previously recorded cultural resources in the project area or vicinity, nor have any cultural resources studies previously been conducted in the project area. Contact with the Native American Heritage Commission and local Native American representatives failed to identify the presence of any traditional cultural properties or sacred sites within the proposed project acreage.

3.4 Constraints

3.4.1 Adjacent Subsided Lands

The property includes approximately 1.5 miles of levees consisting of 1.3 miles of exterior levees and approximately 0.2 miles of an interior “cross” levee. The exterior levees are along Little Honker Bay or adjacent sloughs. DWR surveys conducted during summer 2004 indicate the elevations of the exterior levees range between 6.4 and 9.2 feet NAVD, with an error of 0.5 foot. Overtopping of the levee occurs in several locations during high tides. Figure 9 shows the locations where the levee is less than 7 feet NAVD and susceptible to overtopping in high tides. The width of the levee crown is variable, ranging from 6 to 10 feet.

Significant damage occurred in several locations during the December 2004 - January 2005 high tides, and again during the January 2006 storm event. A California Conservation Crew placed visquine and sandbags in three of the more severely eroded locations during January 2005 to prevent further erosion to these sites (Figure 10). During 2003 and 2004, DWR maintenance crews made repairs to the erosion area at Stn 47+00 (Figure 10). Continued overtopping at this site, and others has resulted in erosion of the pondside levee slope and crown of the levee. It is no longer possible to safely drive a vehicle around the exterior levee as the crown roadway is reduced to less than 6 feet in some areas.

DWR environmental and engineering staff evaluated the severely eroded levee sections and have determined that it is likely that the levee will breach in one or more of these locations unless significant and costly repairs are made. Funding is unavailable to complete major repairs on the levee in these sections. In May 2005, the Advisory Team recommended, and the SMPA Coordinators agreed, to forgo additional costly repairs to the severely eroded levee sections and instead, develop the restoration plan acknowledging the physical constraints of the property.

On December 12, 2005, DWR staff discovered water flowing through a hole in the levee near Stn 52+00. The hole, near the top of the levee on the Little Honker Bay side of the levee, was approximately 18 inches long and 10 inches wide. There was a "sinkhole" about 6 feet from the crown on the pond side of the levee, approximately 4 feet wide, 6 feet long and 5 feet deep. Material had eroded back towards the crown of the levee from the pond side. Because the hole on the Little Honker Bay side is near the crown of the levee, water only flows at tides over 5 feet. DWR engineering staff predicts that subsequent high tides will continue to enlarge the hole and erode the levee material, eventually leading to a levee breach in this location.

Another hole was discovered in the levee during January 2006. This hole, located near Stn. 14+00 was approximately 5 feet long and 2 feet wide on the levee crown. Levee material had eroded away under the crown from the hole (approximately 2/3 of the way across the levee) towards Arnold Slough. Material remained in place along north 1/3 of the levee (pond side). This hole was thought to be caused by beaver activity in the area. This hole was repaired in April 2006.

<u>Cross-Levee</u>
There is a short interior levee (~1,100 feet) between the Blacklock property and the adjacent Blacklock Ranch. Because the poor condition of the exterior levees on the property poses a risk for levee failure and unplanned breaching, this cross levee was raised to elevation 9 feet during September and October 2004. The nine foot elevation will protect the adjacent property from flooding in the event of an unplanned levee failure, and minimize DWR's flood liability, when the property is opened to the tides. All levee work was authorized under the USACE regional general permit 24215N issued to SRCD and DFG. The RGP sets limits on the quantity of material each property is allowed to place; thus DWR was unable to import sufficient material to construct the levee with the desired slope during 2004. Additional material was placed on the (west) slope during the 2005 construction season to restore a 2:1 side slope to the levee. Imported material was used to raise the levee. The material was tested for contaminants prior to placement.

In October 2004, DWR staff revegetated the DWR side of the levee with native grass seed, covered in straw and a jute mat to promote growth of native grasses, reduce weed growth and prevent erosion. This treatment was successful in protecting the levee during the winter of 2004-2005 when the property was inundated as a result of levee overtopping during the high tides. However, this revegetation effort was covered with additional material during the 2005 levee work. During January 2006, the levee slope and toe was revegetated with *Schoenoplectus californicus (*previously called *Scirpus californicus)*. This species will remain viable during the winter months. It is anticipated that this species will colonize up the levee slope with inundation of the parcel when tidal action is introduced to the site.

To protect the levee slope from wind and wave erosion, brush boxes were installed on the cross levee slope in early 2006 as an alternative to rip rap for levee slope protection. Brush boxes are constructed by driving 2 parallel rows of 3-inch diameter wooden poles along the levee slope. Recycled Christmas trees were placed between the poles and secured in place. This method has been used successfully in other areas of Suisun Marsh and in the Sacramento-San Joaquin Delta.

Under existing conditions, the adjacent Blacklock Ranch floods via overtopping of its levees under extremely high tides. This condition occurred during the January 2006 storm event. This flooding is unrelated to the Blacklock Restoration Project. Therefore, while maintaining the cross levee to maintain existing levels of flood protection is a high priority for this project, the purpose is to maintain existing levels of flood protection provided by the restoration site, and not to protect adjacent lands from any flooding.

3.4.2 Abandoned Gas Wells

The property contains two abandoned gas wells. Blacklock Number One was drilled in 1951 and abandoned in 1954. Blacklock Number Two was drilled in 1954 and abandoned in 1972. Both wells were capped and decommissioned according to accepted industry and government standards in 1954 and 1972 respectively (DWR 2003). The wells are classified as being "plugged and abandoned – dry hole" by Weatherford Artificial Lift Systems, Inc., the previous well owner. Weatherford relinquished all rights to Mr. Blacklock in January 2003, and ownership of the wells passed to DWR with purchase of the parcel. No additional work is required on the wells (DWR 2005). The well pad for Blacklock Number One was dismantled and removed from the site; while the well pad for Blacklock Number Two is still intact (Figure 5). Remnants of the roads leading to the well pad still exist on the site.

3.4.3 Vector Control

Since acquiring the property, DWR has worked cooperatively with the Solano County Mosquito Abatement District (SCMAD) to control mosquitos. SCMAD annually samples properties in Suisun Marsh for mosquito production. Prior to DWR acquiring the parcel, SCMAD had records of only two treatments at the site: October 1998 and October 2000. Solano County Mosquito Abatement District inspected the site in October 2004 and found a problem with mosquito production, primarily in the areas dominated by salt grass. SCMAD aerially sprayed the parcel in October 2004 and subsequently billed DWR for vector control. No treatment was necessary in 2005.

The Solano County Mosquito Abatement District (SCMAD) has developed policies for management of tidal marsh restoration. After tidal inundation, DWR will continue to work cooperatively with SCMAD to minimize mosquito production at the site.

3.4.4 Non-native vegetation

While much of the vegetation on site is native, desirable marsh species, several acres of *Phragmites australis* are present in the ponds. This species is a rapidly spreading weed that out competes native emergent vegetation. It is a problem throughout Suisun Marsh, and marshwide eradication/control programs have been initiated. An invasive species monitoring and control program is discussed in section 5.2.6.

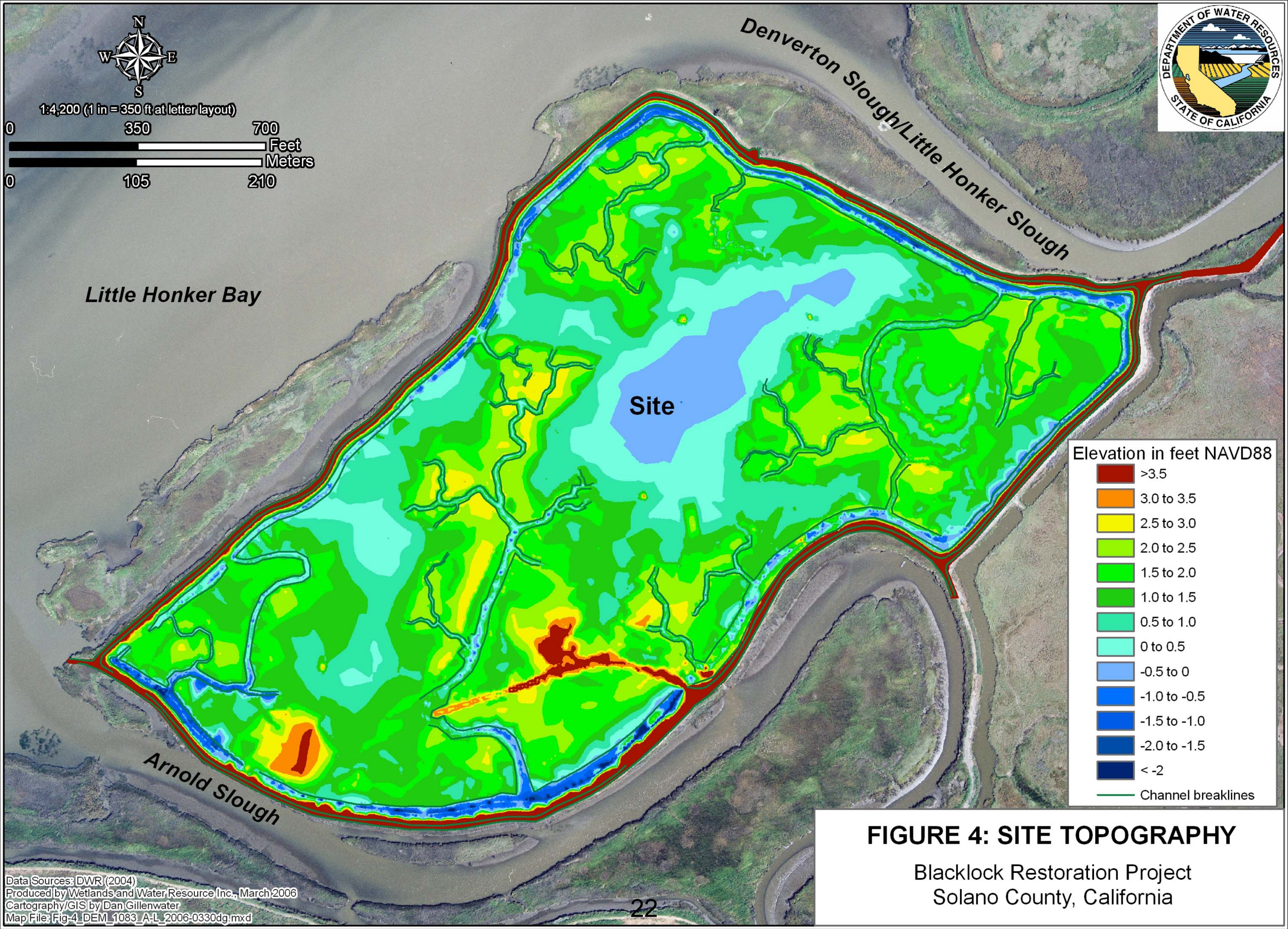


FIGURE 4: SITE TOPOGRAPHY

Blacklock Restoration Project
Solano County, California

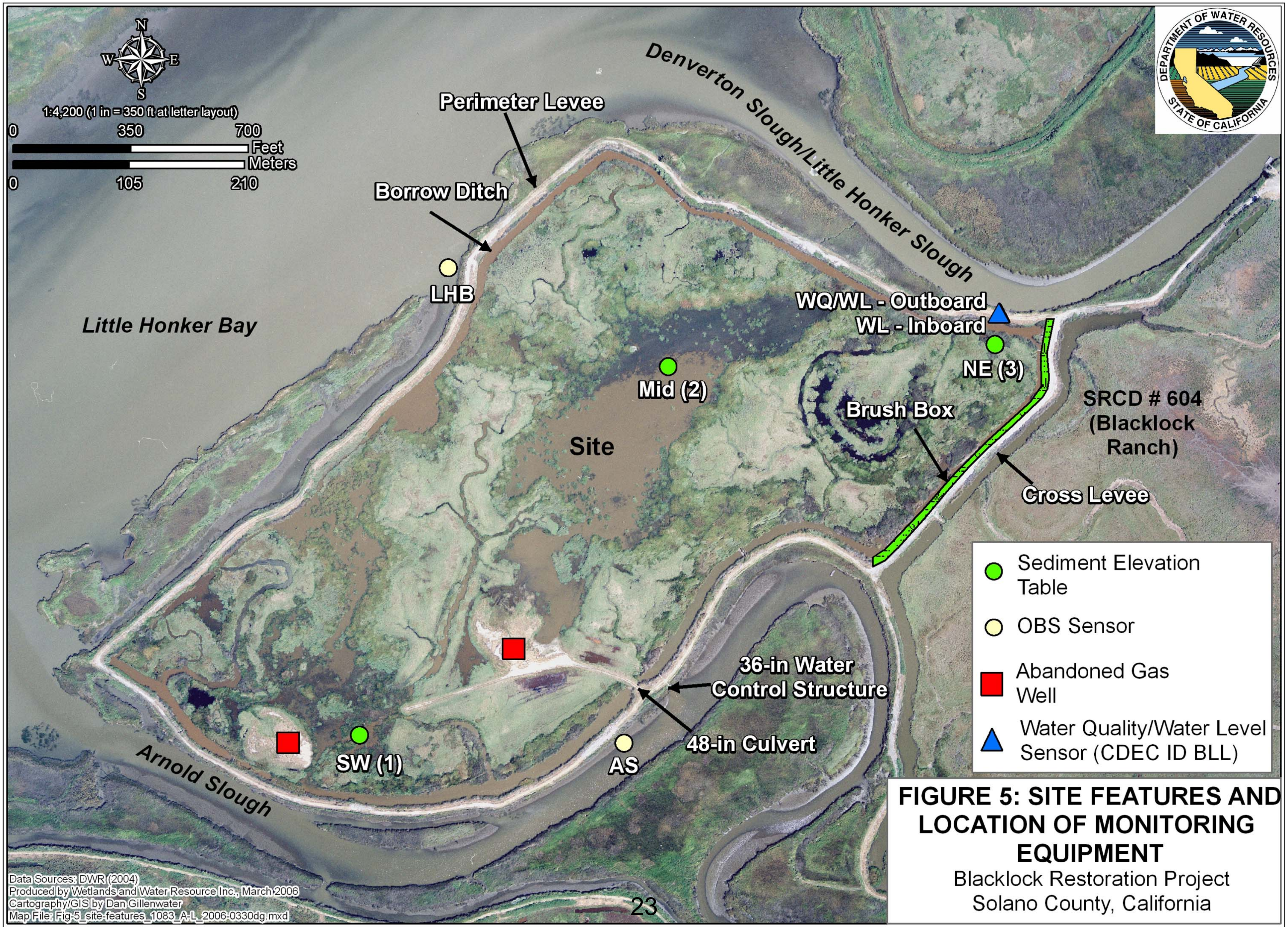
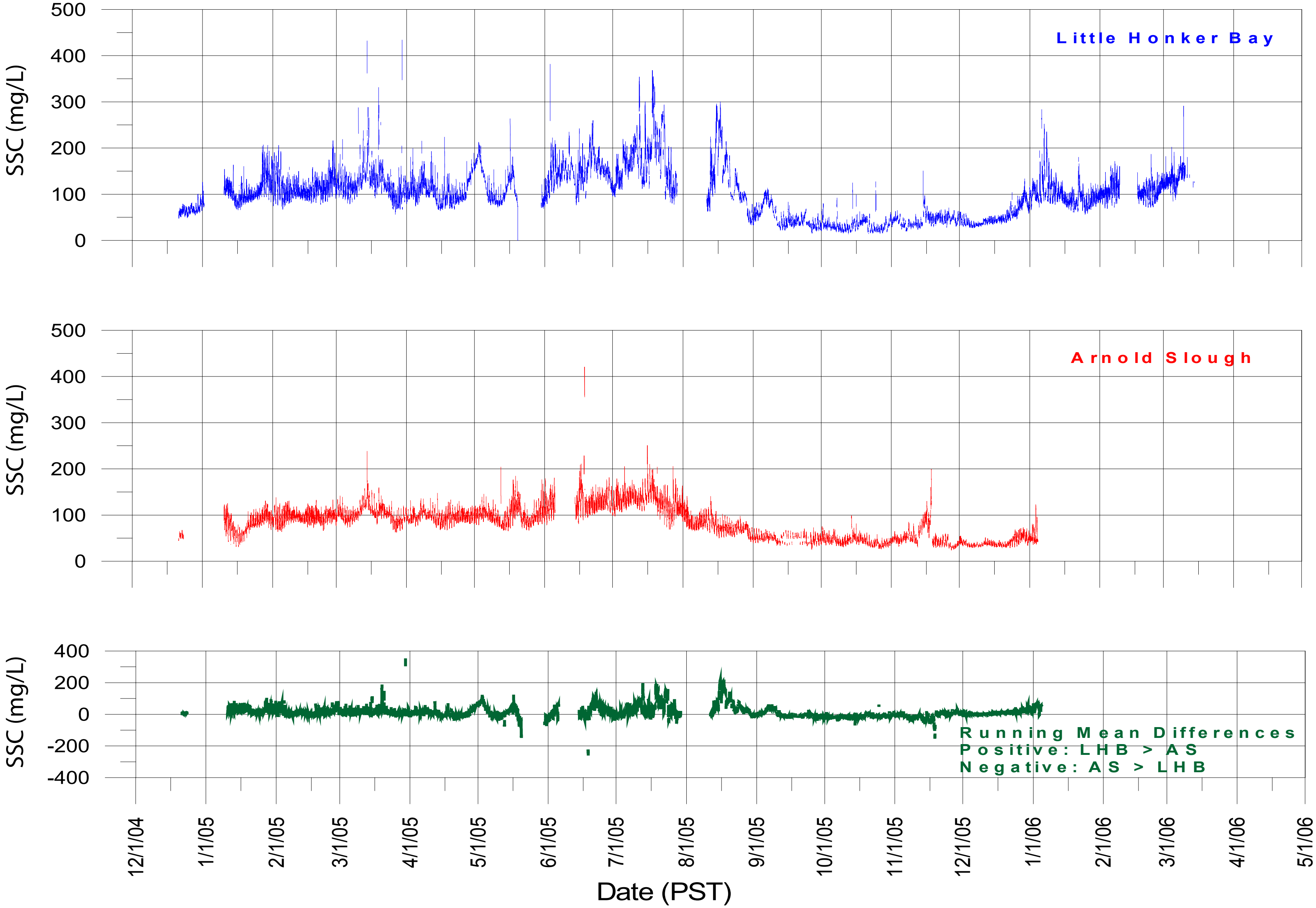


FIGURE 5: SITE FEATURES AND LOCATION OF MONITORING EQUIPMENT

Blacklock Restoration Project
Solano County, California



	Arnold Slough	Little Honker Bay
Maximum	420	499
75th Percentile	104	126
Mean	82	98
Median	85	96
25th Percentile	51	57
Minimum	4	14

DEPARTMENT OF WATER RESOURCES
STATE OF CALIFORNIA

FIGURE 6: SUSPENDED SEDIMENT CONCENTRATIONS AND COMPARISONS

Blacklock Restoration Project
Solano County, California

\\Server3\wwr_network\Active_Projects\1083_Blacklock\113-RestPlan\RP Figures Mar 2006\Fig-6_OBS_SSC Plot 2006-00403sra

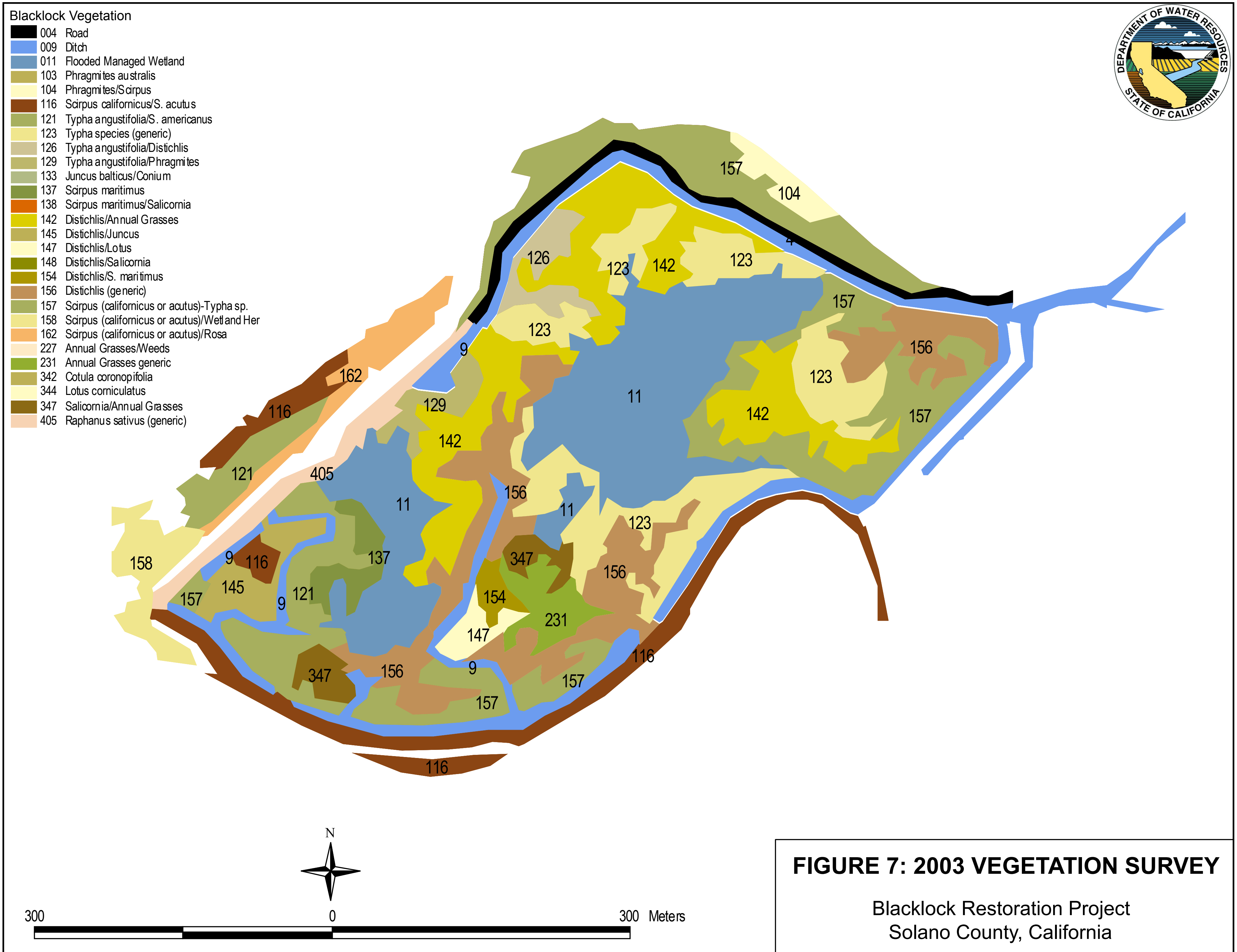


FIGURE 7: 2003 VEGETATION SURVEY

Blacklock Restoration Project
Solano County, California

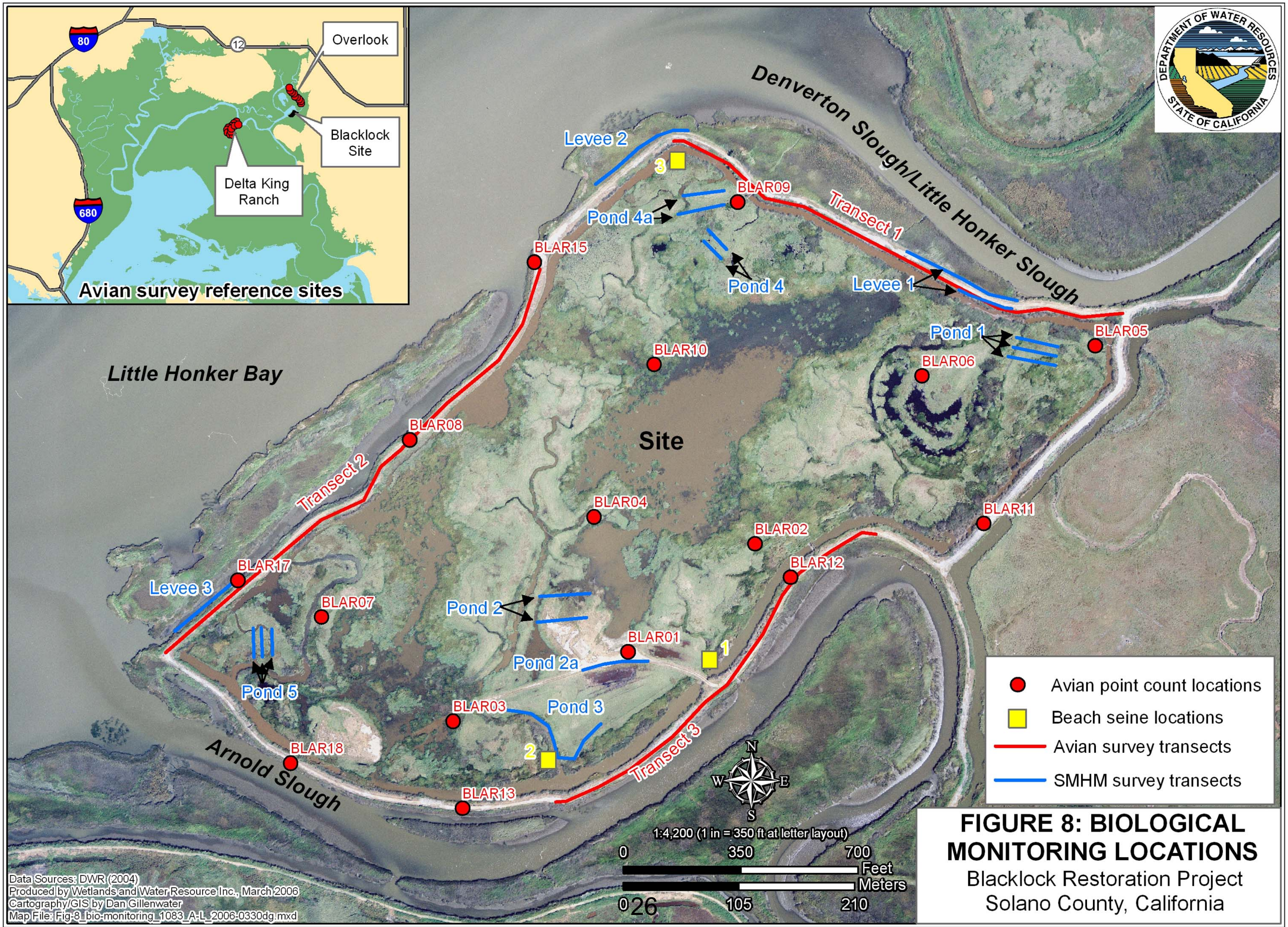


FIGURE 8: BIOLOGICAL MONITORING LOCATIONS
Blacklock Restoration Project
Solano County, California

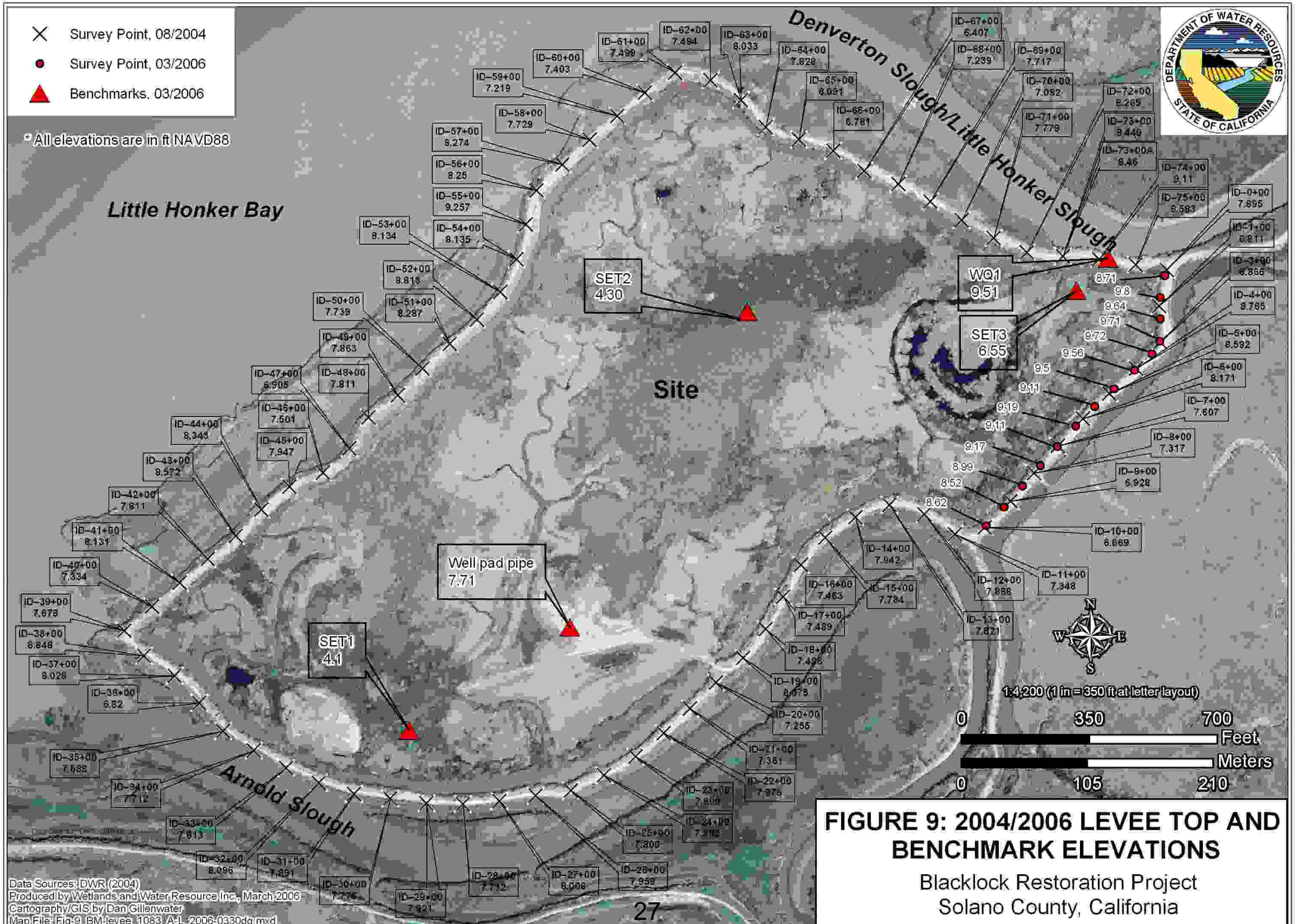


FIGURE 9: 2004/2006 LEVEE TOP AND BENCHMARK ELEVATIONS

Blacklock Restoration Project
Solano County, California

4.0 DESCRIPTION OF PROPOSED PROJECT

This section describes the proposed restoration efforts needed to implement the project. The underlying restoration requirement for this site is subsidence reversal, as the site ranges from 3 to more than 5 feet below local mean high water. The overall approach for the Blacklock Restoration Project calls for a passive strategy in which the exterior levee is breached, natural sedimentation and plant detritus accumulation restores intertidal elevations, and natural colonization establishes the plant and wildlife communities. The project includes a "pre-vegetation" element to promote these natural restoration processes. Tidal flow is expected to utilize the existing remnant channels to some extent, with some new channels forming as sedimentation progresses. This design is a minimal-engineering approach that relies on natural processes to meet project goals and objectives.

Because of the poor condition of the exterior levee, an unintended levee failure may occur prior to implementation of a final plan. Therefore, two alternative approaches are presented to address this uncertainty.

4.1 Proposed Levee Breaches

4.1.1 Identifying Options

To achieve project goals and objectives of restoring the Blacklock property to a self-sustaining functioning brackish tidal marsh, candidate breach locations were evaluated to optimize import and deposition of adjacent channel sentiment to the site. The location of levee breaches has a significant influence on subsidence reversal through sediment accretion and vegetation development.

The effectiveness of a levee breach for importing sediment depends on several factors including orientation to prevailing wind, channel depth adjacent to the levee breach, topography of the area behind levee breach, remnant channel location, and vegetation composition.

- Orientation to prevailing wind. In general, the breaches oriented to receive prevailing wind fetch are more likely to receive suspended sediment on flood tides, especially during fair wind afternoon periods.
- Adjacent channel sediment availability. The availability of suspended sediment in adjacent channels is partly a function of channel depth. Breaches near shallow channels or shoals may import higher suspended sediment concentrations.
- Site topography behind levee breach. An important element of promoting suspended sediment influx into a restored site is the ability to transport sediment throughout the site. Breaches should be located adjacent to low points within the site interior so as to facilitate tidal transport of suspended sediment throughout the site.
- Remnant tidal sloughs. To the extent possible breaches should be located to take advantage of remnant tidal creek channels to conduct tidal energy further into the site and to re-establish those channels as natural channels to the extent possible.
- Vegetation composition. Similar to the topography immediately behind levee breach, vegetation composition will also control tidal energy penetration. Tidal energy will enter the restoration site as a "jet" with significant shear flow to either side of the maximum velocity zone. It is desirable to locate levee breaches such that the high velocity zone is relatively unobstructed by vegetation.

4.1.2 Hydrodynamic Modeling to Evaluate Options

DWR staff utilized hydrodynamic modeling as a planning and predictive tool to investigate alternative breach options for the Blacklock Restoration Project. RMA2, a depth-averaged two-dimensional hydrodynamic model (King, 1997), was used to simulate the water levels on the Blacklock property and its vicinity. Using a turbulence sub-model to represent the local effect of velocity gradients, RMA2 applies the finite element method to solve the equations of mass and momentum conservation, thus describing the depth-averaged two-dimensional unsteady hydrodynamics within the water body. The model has the capability to simulate irregular boundaries, dry and wet node conditions and sub-surface flows on tidal wetlands.

The RMA model is based on the equations of mass and momentum conservation (Navier-stokes equations). Since these equations are deterministic, error margin is not of a concern (unlike statistical formulations). Navier-stokes equations are able to describe a flow field very accurately given boundary conditions. In contrast, there are several sources of uncertainty that are likely greater than any error in the model formulation. These include uncertainty about friction due to variable vegetation, and general uncertainty about the location and nature of natural levee breaches as they made it appear at the site. The model is used to highlight the sensitivity of the flow field inside Blacklock to these very frictional and geometric uncertainties. The Bay Delta RMA2 model was provided by Resource Management Associates Inc.

4.1.2.1 Modeling Scenarios

Several breach scenarios were modeled. Scenarios evaluated effects of varying locations, widths, and numbers of breaches. The first set of scenarios investigated the impact of breach size on Blacklock water levels. Two conditions were considered: the first adds a 10 meter levee breach at station 55+00 (Scenario 1) (Figure 10), the second adds a levee breach at the same location but increases the breach width from 10 meters to 20 meters (Scenario 2). Both scenarios have the breach footing elevation at -0.34 meters NAVD. The second set of scenarios investigated the impact of breach locations. The breach was made at station 47+00 (Scenario 3) and station 55+00 (Scenario 4), respectively. Both scenarios have a breach width of 20 meters and the breach footing elevation at -0.34 NAVD. A third set of scenarios investigated the impact of the number of breaches. Two conditions were assumed for this investigation, one with a breach at station 55+00 (Scenario 5) and the other with three breaches at stations 36+00, 47+00 and 55+00 (Scenario 6). All the breaches have a width of 20 meters and a footing elevation at -0.34 meter NAVD. Finally, the sensitivity of the model, specifically the model's sensitivity to the bed roughness coefficient, was investigated. Three bed roughness coefficients (n = 0.07, 0.15 and 0.25) were considered for the sensitivity study. The levee breach condition was assumed to be the same as Scenario 1. The summary of scenarios is presented in Table 4. Modeling results are summarized below.

4.1.2.2 Modeling Results

<u>The Impact of breach size (Scenarios 1 and 2)</u>. Increasing the breach width from 10 meters to 20 meters did not significantly affect Blacklock water levels. Figures 11 and 12 show the water levels at node 4993 (east side of the property, bottom elevation 0.25 meter NAVD) and node 5457 (west side of the property, bottom elevation 0.045 NAVD) for the different levee breach configurations. Very little difference in the water levels can be seen between the two scenarios.

Table 4 - Summary of Modeling Scenarios

Group	Scenario	Breach Location	Breach Configuration	
			Width(m)	Footing Elevation (m NGVD)
Breach Sizes	1	Stn 56+00	10	-1.17
	2	Stn 56+00	20	-1.17
Breach Locations	3	Stn 47+00	20	-1.17
	4	Stn 56+00	20	-1.17
Breach Number	5	Stn 56+00	20	-1.17
	6	Stn 56+00 Stn 47+00 Stn 36+00	20	-1.17

<u>The impact of breach location (Scenarios 3 and 4)</u>. Location of the breach significantly affected the low tide water levels. Figures 13 and 14 show water levels at nodes 4993 and 5457 for the breaches made at stations 47+00 and 56+00. Station 47+00 is behind an island and is relatively hidden while station 56+00 has a direct connection to Little Honker Bay. Comparing the simulation results with the two breach locations, it is apparent that during low tides Blacklock water levels are lower if the breach was made at a location with a direct connection to the bay. The difference in the water levels between Scenarios 3 and 4 can be as high as 0.18 meter (7 inches) during a low tide. High tide water levels did not appear to differ significantly. This finding is significant for selecting a suitable breach location when water levels during low tides are of a main concern for certain species in the restoration process.

<u>The impact of the number of breaches (Scenarios 5 and 6)</u>. The number of breaches also affected Blacklock water levels. Figures 15 and 16 show the water levels at nodes 4993 and 5457 for one breach and three breach conditions, respectively. Under a multiple (three) breaches condition, it was easier for water to be drained out of the property thus led to lower water levels during low tides. At node 4993, the difference in water level during low tide can be as high as 0.19 meter (7.6 inches) between the one-breach and three-breach conditions. As with scenarios 3 and 4, high tide water levels were not significantly different.

<u>Model Sensitivity</u>. The model is sensitive to bed roughness coefficients (i.e., Manning's n). The higher the Manning's n, the higher the friction head loss, thus the lower the velocities and the higher the water levels. Figures 17 and 18 show the differences in water levels simulated with Manning's n equals 0.07, 0.15 and 0.25 in heavily vegetated areas. At node 5457, the difference in the water levels can be as high as 0.1 meter (3.8 inches) with n = 0.07 and n = 0.25 respectively.

<u>Other simulation results</u>. For Scenarios 1 through 6, during high tides, the water levels inside of the Blacklock property are the same as those on Little Honker Bay (Figures 19 and 20). However, during low tides, the water levels inside of the Blacklock property are always higher than those on Little Honker Bay. This may

have resulted from the high friction loss caused by heavy vegetation on the property preventing water from draining during low tide.

It was also found that for Scenarios 1 through 6, the flow field on Blacklock is asymmetrical (Figures 21 and 22): it has longer ebb periods and lower velocities while the flood periods are shorter and velocities are higher. This asymmetry in flow field may provide a potential mechanism for sediment to be trapped in the Blacklock property thus facilitate the marsh restoration processes if sediment supplies from the bay are high.

4.1.2.3 Additional Modeling Needs

Because sediment transport is important for tidal wetland restoration, DWR modeling staff recommend that future modeling include a sediment transport model for the Blacklock property and vicinity to study the sediment transportation and deposition.

In addition, DWR modeling staff recommend future modeling include a water quality model for the Blacklock property to evaluate possible water quality issues involved in the restoration process.

The hydrodynamic, sediment and water quality models would need to be calibrated and verified when the stage, flow, sediment and water quality data at the Blacklock property are available.

4.2 Restoration Approaches

4.2.1 Preferred Approach: Constructed Levee Breaches

Modeling results indicate that the site drains better at low tide with two breaches on the property. Therefore, two locations, 55+00 and 25+00 are identified as preferred breach locations for the constructed breach alternative. Station 55+00, along Little Honker Bay (Figure 10) would allow for an unimpeded exchange of flows during tidal cycles. Because there is no in-channel island or fringing tidal marsh here, it is expected that a breach at this location would optimize the transport of available Little Honker Bay sediments into the property to raise surface elevation through sediment deposition. In addition, a breach at this location could take advantage of the remnant tidal slough network within the property. It is unlikely that an unintended levee failure would occur at this location. The levee is wider and higher than other areas and there is riprap on the waterside slope and toe.

The second breach would be located along Arnold Slough, preferably at 25+00, which lines up nicely with an existing channel and would serve the southwest corner well. An alternate location for the second breach is near 35+00, which is close to an existing channel but avoids the outboard marsh (a viable alternative to 25+00). In addition, the levee is highly eroded at the southwest corner of the property. One consideration in determining preferred breach location is that when the tide enters through a breach, it's most likely to continue in a straight line for some reasonable distance before meandering; just south ("right") of the 55+00 breach, once past the borrow ditch, is higher ground, which could have the effect of limiting tidal exchange to the southwest corner. Thus a breach between 20+00 and 53+00 would serve the southwest corner well.

Modeling suggests that a breach size of at least 65 feet (20 meters) would be sufficient for full tidal exchange.

4.2.2 Secondary Approach: Unintended Levee Failure

Much of the exterior levee of this parcel is in poor condition. In addition to the hole near Stn 52+00, several areas along the exterior levee are severely eroded (Figure 10). Erosion is most severe at Stn. 47+50 and from 36+00 to 38+00. Without additional maintenance to the levee near Stn 52+00 and other severely eroded areas, DWR and SRCD staff as well as Dr. Siegel (Science Advisor) expect that a breach at one or more of these locations will occur within the next year, and possibly sooner.

In the event of an unintended levee failure at one of the expected or another location along the exterior levee, the site will be monitored to assess whether project goals, objectives and desired outcomes are being achieved. Specifically, monitoring will focus on the tidal regime inside the parcel, evolution of the breaches, tidal exchange through the breach, marsh development, sediment accretion and elevation changes within the subsided lands. Biological objectives will also be evaluated including what fish species are using the site and vegetation development.

The Advisory Team will use this information to evaluate if the unplanned breach is sufficient for development of a functioning tidal marsh ecosystem. If not, the site will be adaptively managed (as described below) to promote full tidal exchange and tidal marsh development. Options include increasing the size of the natural breach, deepening the natural breach, or creating additional breaches in the exterior levee. The likely location of an additional breach would be at 55+00.

4.3 Construction Methods

Under the proposed constructed alternative, the levee would be breached by excavating the levee during low tide. The levee would be breached during one low tide cycle, and would be scheduled to coincide with the lowest (projected) tide during the available construction window.

All heavy equipment would access the site from the levee. In each location a 65 foot (20 meter) breach will be constructed using a long-reach excavator. Material would be removed to a depth of 1 foot NAVD to allow unimpeded tidal exchange during a tidal cycle. A maximum of 1000 yards of material would be excavated from each breach. Excavated material would be used to raise low areas of the exterior levee, placed as ditch blocks or in ponds as subsidence reversal material. Any material placed on the exterior levee would be graded when dry, if heavy equipment can access the site after the breach. Any material placed in the ponds would be not be compacted, but left as placed.

Access for heavy equipment would be from Shiloh Road, through the Blacklock Ranch (ownership 604), and to the site. DWR acquired an easement through this parcel when the restoration site was acquired in 2003.

Pre-construction environmental documentation would be prepared and included as part of a Nationwide Permit 27 issued by the USACE. All permit conditions and construction best management practices (BMPs) will be followed to minimize impacts to the project area and sensitive habitats. A qualified biologist will be on site at all times during construction.

4.4 Operations and Maintenance

4.4.1 Cross Levee Maintenance

To prevent flooding of the Ownership #604, Blacklock Ranch, the cross-levee was raised to 9.0 feet NAVD during 2004. During 2005, additional material was added to the cross-levee to restore the 2:1 side slope on the proposed restoration side of the levee. The base of the cross-levee was revegetated with *Schoenoplectus californicas* in 2005. Brush boxes were installed on the cross-levee slope in early 2006 to provide wavewash erosion protection. In addition, woody vegetation was planted on the levee slope above the brushboxes. The brushboxes are expected to provide erosion protection for 3-5 years, giving time for the revegetated levee to mature. This alternative approach to protect the levee slope will be evaluated for effectiveness. If the brushboxes do not provide adequate protection, additional measures will be considered.

The east (non-project) side of the levee sustained moderate damage during the January 2006 storm and high tide event. The adjacent property flooded during the high tides and wind fetch across the open water of the adjacent parcel resulted in erosion to the east side of the cross levee. Once permits and material are obtained, this side of the levee will be repaired and revegetated. Maintaining the cross levee is, and will continue to be, a high priority.

4.4.2 Exterior Levee Maintenance

Maintenance on a portion of the exterior levee from 56+00 to 75+00 will continue to occur until the levee is breached at 55+00. In the event of an unintended levee failure, maintaining the levee from 55+00 to 75+00 is necessary to allow the excavating equipment access to the preferred breach location, unless a decision is made that a breach at the preferred breach location is not necessary. Sections of this levee, specifically around 64+00 through 69+00 are some of the lowest on the property, and frequently overtop at tides over 6.2 feet NAVD. However, since there is a wide fringing marsh in this location, which dissipates the energy of the high tides, this area does not have the heavily eroded waterside slope of other areas. Maintenance of this levee would likely include placing imported material to raise the levee and maintain access for equipment necessary to breach the levee, if needed.

In addition, the exterior levee will also be maintained from 11+00, the end of the cross levee to 25+00 until a determination is made that unimpeded tidal exchange is achieved. Maintaining this section of levee along Arnold Slough will allow access from the cross levee to the water control structure and culvert under the well pad road.

Vegetation control including mowing and weed control will continue along the crown of the exterior levee to allow pedestrian access for as long as is practical. This will allow agency staff and those involved with the restoration access to evaluate levee and site conditions, and conduct monitoring. Access will be limited to foot traffic and ATV's since the levees are unsafe for larger vehicles.

It is expected that the remaining exterior levees will erode over time, resulting in additional breaches.

4.4.3 Vector Control

SCMAD BMP's will be followed to control mosquito production on restored wetlands at Blacklock. DWR will continue to work with the SCMAD to minimize mosquito production. The site will be treated as necessary at the recommendation of SCMAD.

4.4.4 Invasive Species Control

Exotic plants and animals often thrive under conditions at wetland restoration sites (Zedler, 2000). A program for the control of non-native invasive plant species will be developed as part of the vegetation monitoring plan for this project (see Section 5.2.6). Control of aquatic invasive species is likely to be difficult and will be best achieved by providing conditions more favorable to native species.

4.5 Adaptive Management

Adaptive management means taking informed, intentional actions designed to achieve pre-defined goals and objectives, observing the effects of those actions over a prescribed time period, evaluating the observed outcomes of those actions against a set of pre-defined criteria, and determining whether further actions should be taken based on those evaluations (Lee, 1993). In this adaptive management framework, it is critical to consider up-front what range of *feasible* actions could be taken, so that monitoring and decision making are focused on elements where intervention is possible and likely to have a measurable effect.

Whether tidal inundation occurs at Blacklock under a planned or unplanned event, adaptive management will be incorporated, as needed, to meet project goals and objectives. Physical and biological parameters will be monitored to evaluate success in meeting desired outcomes and to minimize undesirable outcomes. Physical parameters including tidal regime and breach geometry will be used as an indicator for future actions. Monitoring these physical parameters, in addition to using the computer model as a predictive tool, will inform project planners on specific actions that might be implemented. One important component of biological monitoring will be the use of this restoration site by listed species. Adaptive management will be incorporated, as needed and practical, to meet the goal of providing suitable habitat for listed species.

Because the existing conditions of the exterior levees suggest that levee failure would occur in some location other than our preferred breach location, deepening or widening of the breach may be required to achieve full, unimpeded tidal flow. Under the unplanned breach scenario, site conditions will be monitored and observed for at least one year to allow time for evolution of the breach.

The Adaptive Management Program for the Blacklock Restoration Project consists of the following elements:

- Milestone #1: At one year following breach (whether planned or unintentional), results of several monitoring parameters will be evaluated to determine whether any further actions are needed: the degree of tidal inundation, amount of sedimentation, breach geometry evolution, vegetation community changes, mosquito production, and invasive species colonization. These data will inform whether levee breaches need to be enlarged, new levee breaches added, or invasive vegetation control needed.

- Milestone #2: At two years following implementation of any changes following review at Milestone #1, results of the same parameters plus overall wildlife use and aquatic species use will be evaluated. These data will inform whether any final measures are warranted to alter the course of the site development to promote meeting its goals and objectives.

- Monitoring data review: In between and following these two milestones, monitoring data will be reviewed along with site observations made during monitoring, for early detection of desired or undesirable outcomes. If these reviews indicate clear adverse conditions prior to reaching either milestone, actions under those milestones would be moved forward as deemed appropriate by DWR and its Advisory Team.

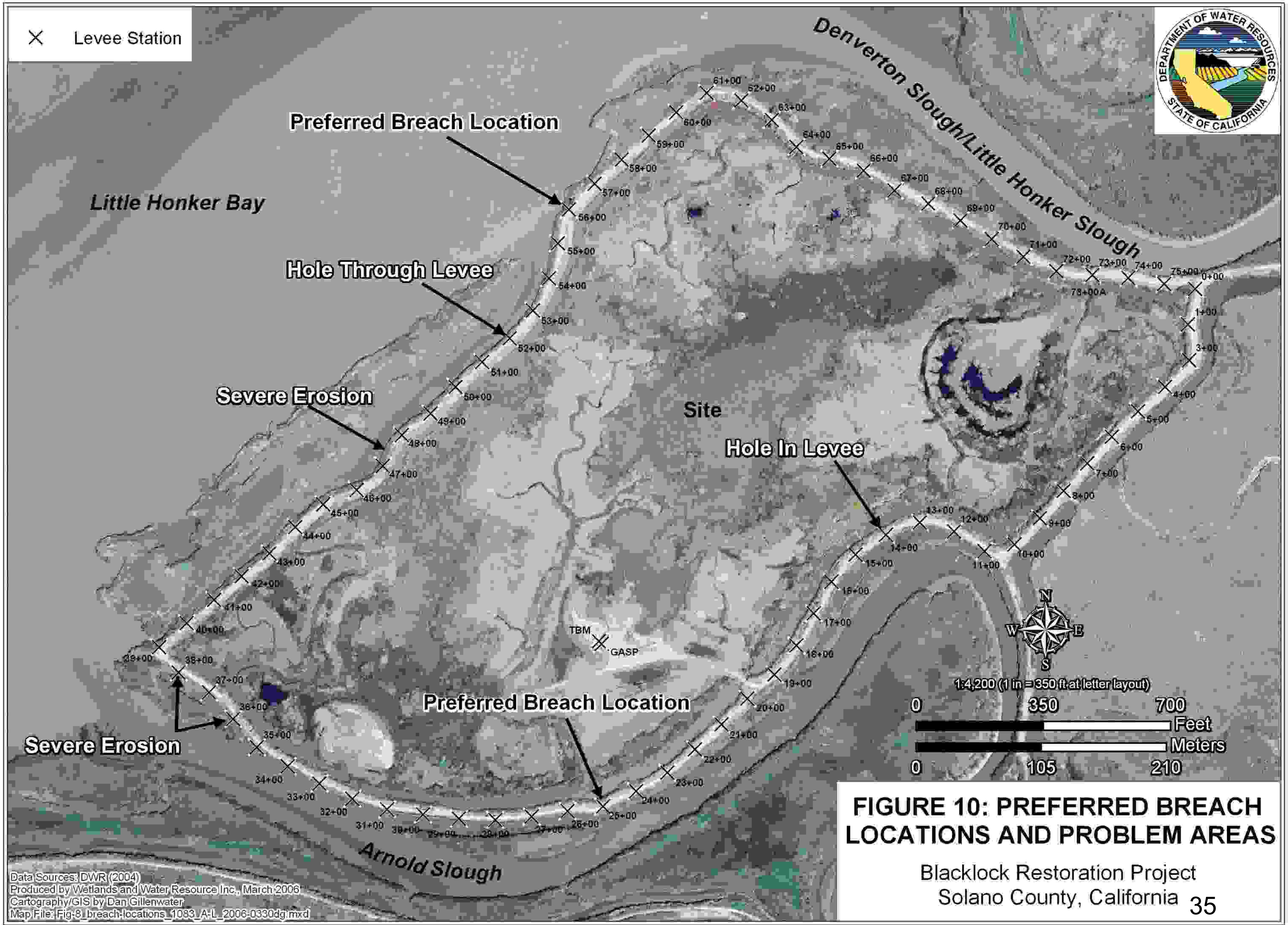


FIGURE 10: PREFERRED BREACH LOCATIONS AND PROBLEM AREAS

Blacklock Restoration Project
Solano County, California

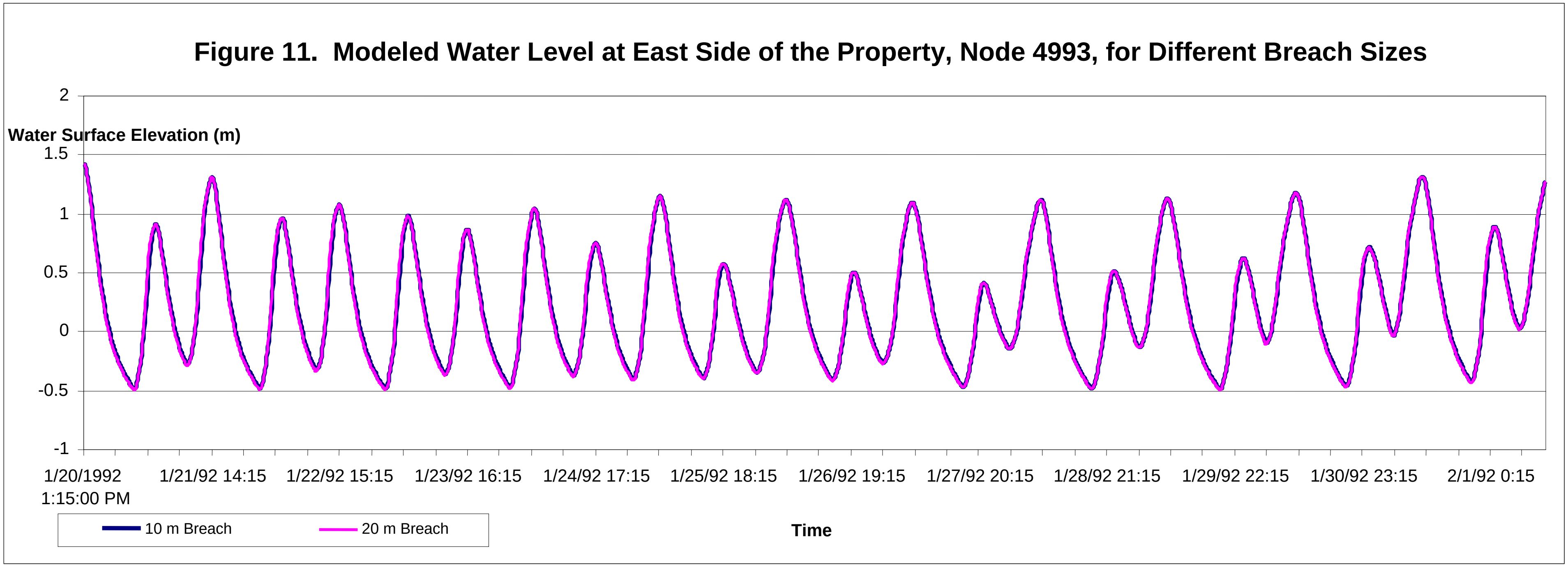


Figure 11. Modeled Water Level at East Side of the Property, Node 4993, for Different Breach Sizes
Water Surface Elevation (m)
2
1.5
1
0.5
0
-0.5
-1
1/20/1992 1:15:00 PM
1/21/92 14:15
1/22/92 15:15
1/23/92 16:15
1/24/92 17:15
1/25/92 18:15
1/26/92 19:15
1/27/92 20:15
1/28/92 21:15
1/29/92 22:15
1/30/92 23:15
2/1/92 0:15
10 m Breach
20 m Breach
Time

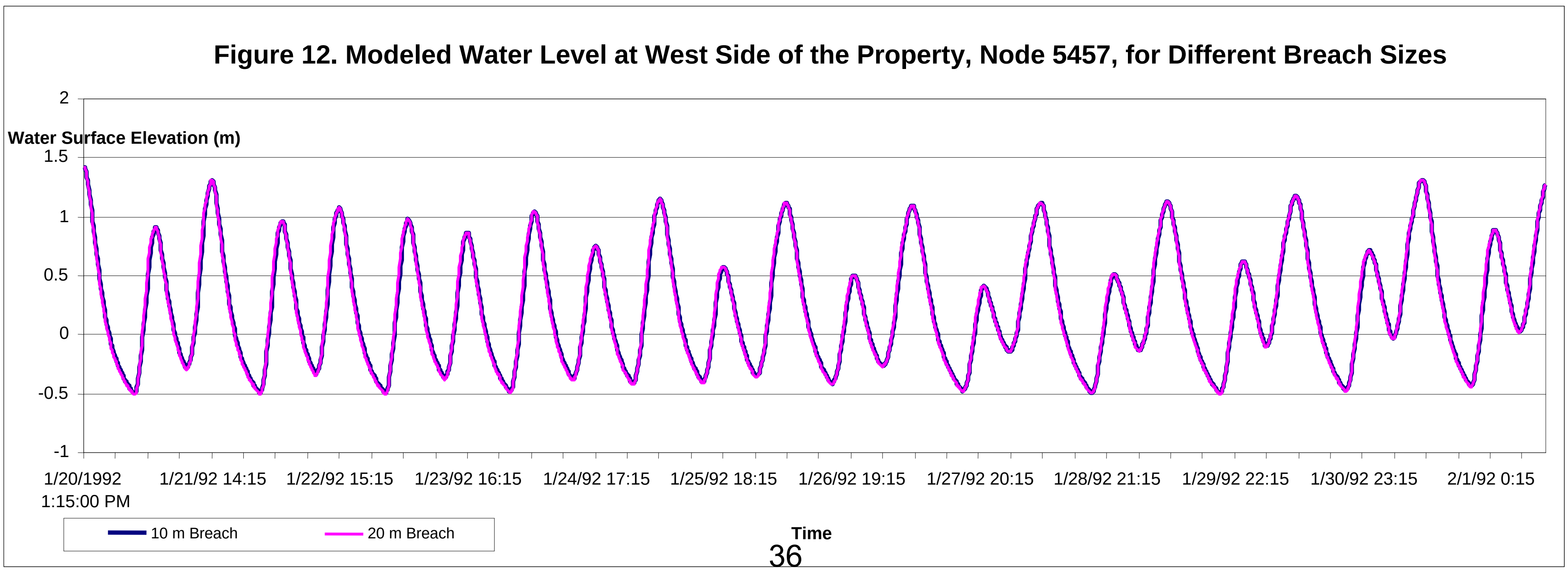


Figure 12. Modeled Water Level at West Side of the Property, Node 5457, for Different Breach Sizes
Water Surface Elevation (m)
2
1.5
1
0.5
0
-0.5
-1
1/20/1992 1:15:00 PM
1/21/92 14:15
1/22/92 15:15
1/23/92 16:15
1/24/92 17:15
1/25/92 18:15
1/26/92 19:15
1/27/92 20:15
1/28/92 21:15
1/29/92 22:15
1/30/92 23:15
2/1/92 0:15
10 m Breach
20 m Breach
Time

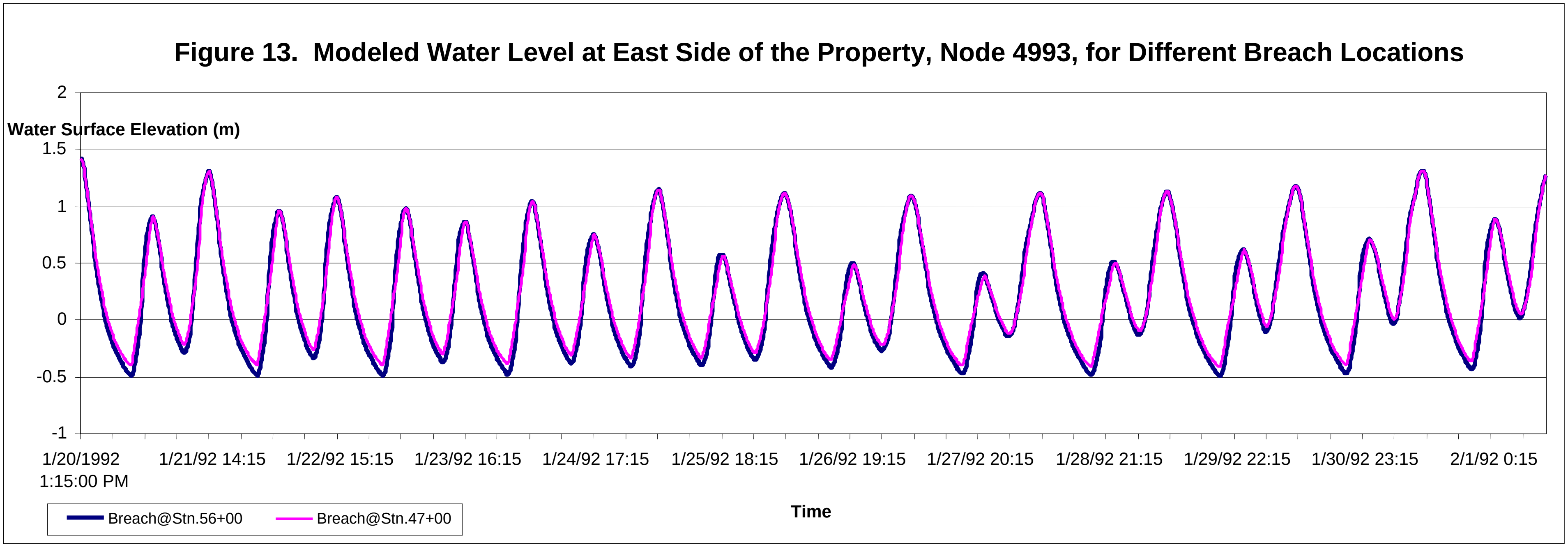


Figure 13. Modeled Water Level at East Side of the Property, Node 4993, for Different Breach Locations
Water Surface Elevation (m)
2
1.5
1
0.5
0
-0.5
-1
1/20/1992 1:15:00 PM
1/21/92 14:15
1/22/92 15:15
1/23/92 16:15
1/24/92 17:15
1/25/92 18:15
1/26/92 19:15
1/27/92 20:15
1/28/92 21:15
1/29/92 22:15
1/30/92 23:15
2/1/92 0:15
Time
Breach@Stn.56+00
Breach@Stn.47+00

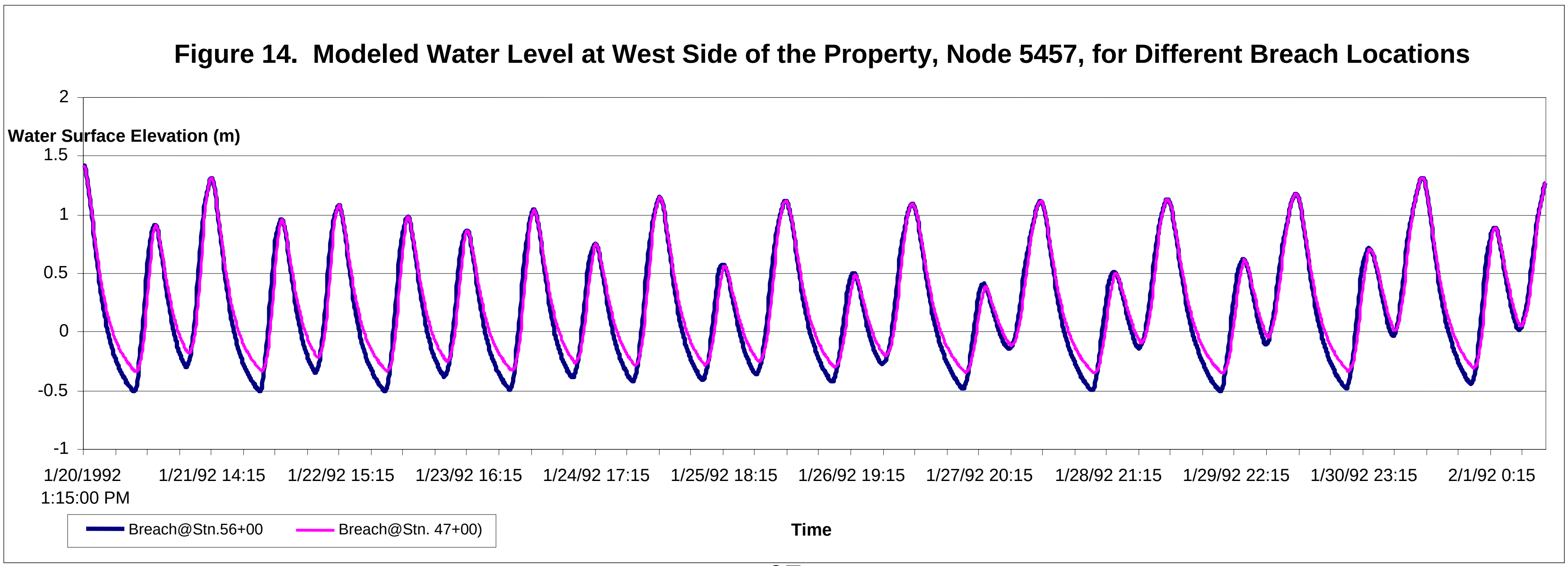


Figure 14. Modeled Water Level at West Side of the Property, Node 5457, for Different Breach Locations
Water Surface Elevation (m)
2
1.5
1
0.5
0
-0.5
-1
1/20/1992 1:15:00 PM
1/21/92 14:15
1/22/92 15:15
1/23/92 16:15
1/24/92 17:15
1/25/92 18:15
1/26/92 19:15
1/27/92 20:15
1/28/92 21:15
1/29/92 22:15
1/30/92 23:15
2/1/92 0:15
Time
Breach@Stn.56+00
Breach@Stn. 47+00)

Figure 15. Modeled Water Level at East Side of the Property, Node 4993, for Different Number of Breaches

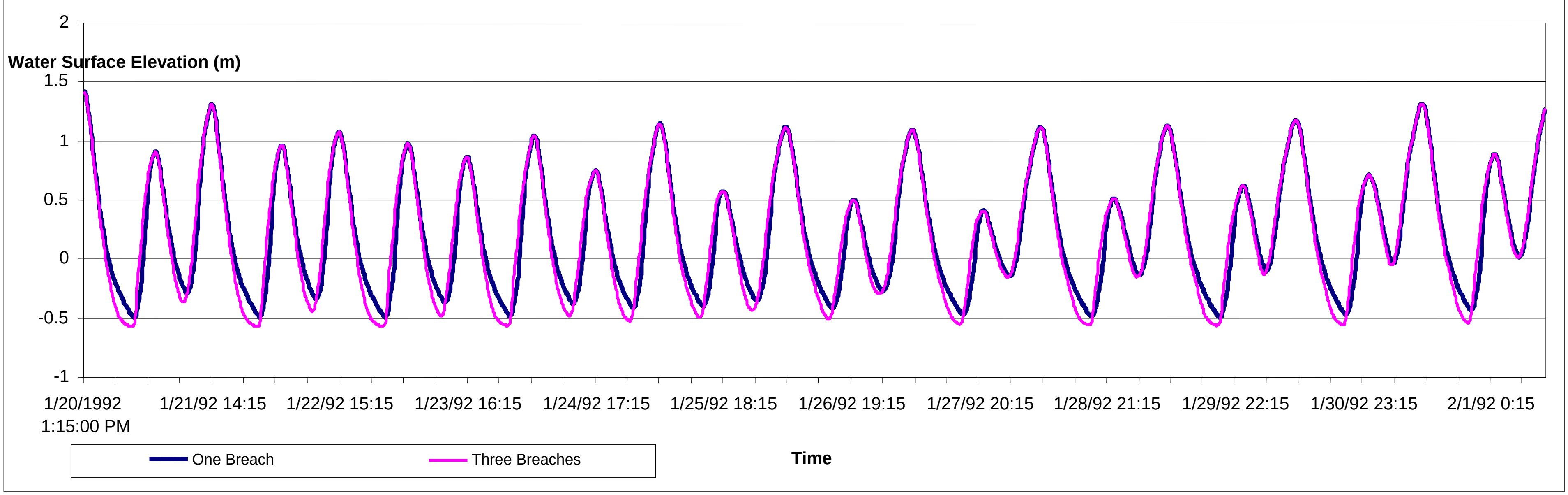
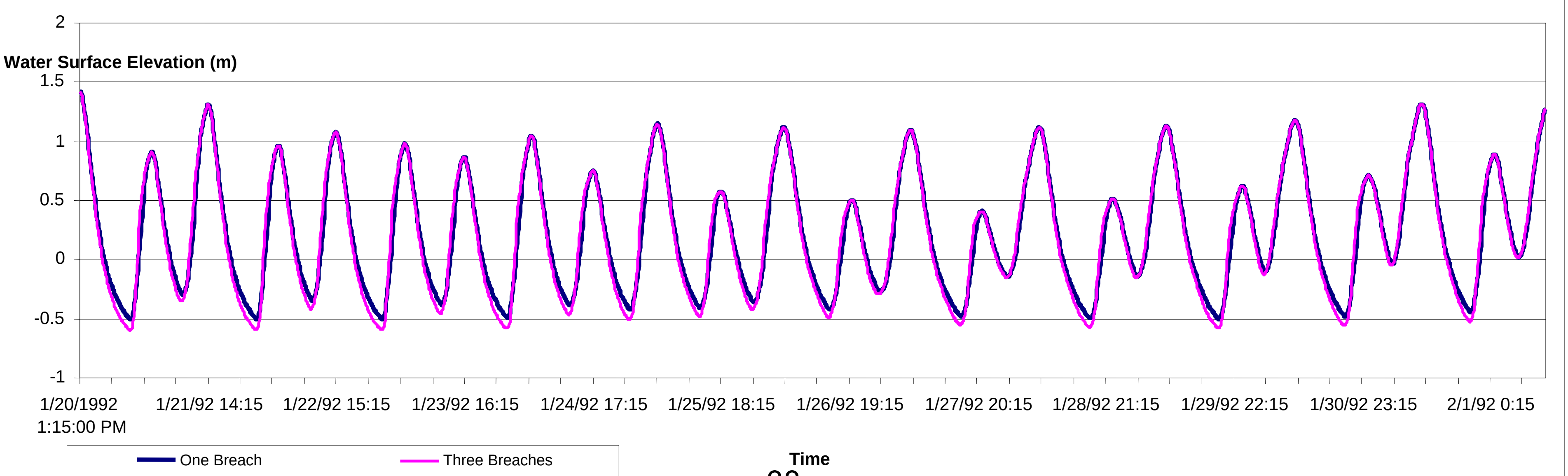


Figure 16. Modeled Water Level at West Side of the Property, Node 5457, for Different Number of Breaches



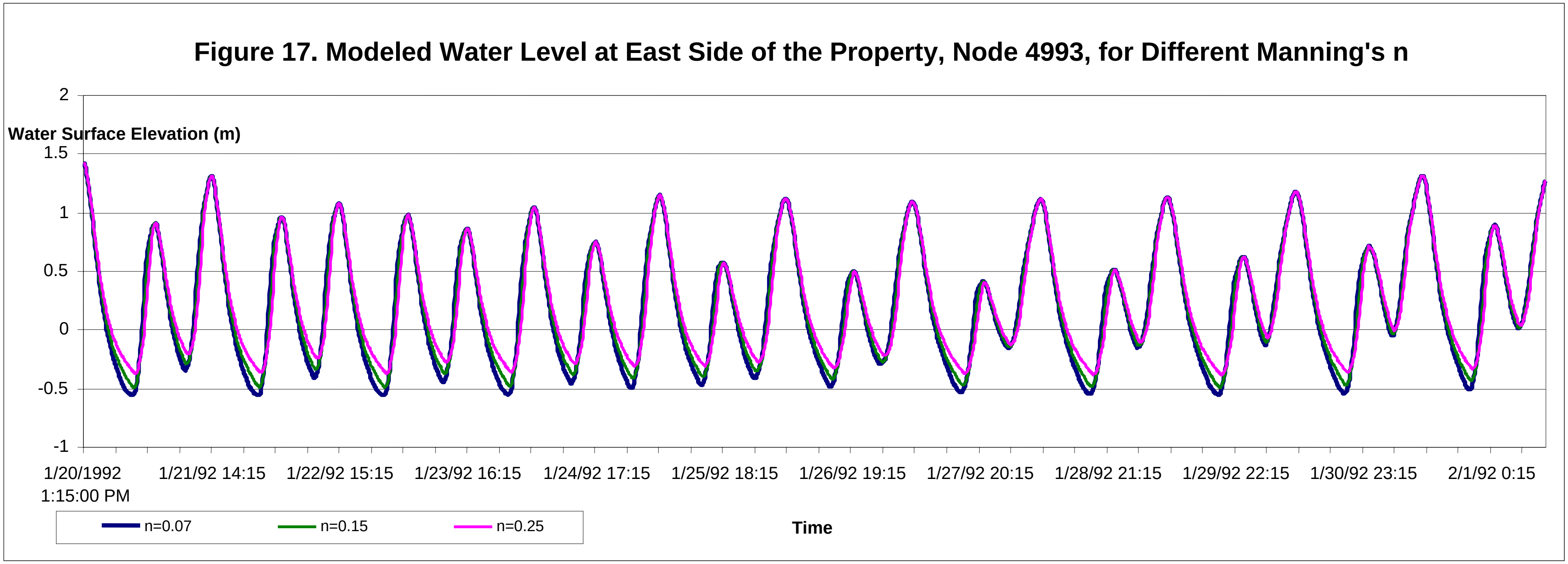


Figure 17. Modeled Water Level at East Side of the Property, Node 4993, for Different Manning's n
Water Surface Elevation (m)
2
1.5
1
0.5
0
-0.5
-1
1/20/1992 1:15:00 PM
1/21/92 14:15
1/22/92 15:15
1/23/92 16:15
1/24/92 17:15
1/25/92 18:15
1/26/92 19:15
1/27/92 20:15
1/28/92 21:15
1/29/92 22:15
1/30/92 23:15
2/1/92 0:15
n=0.07
n=0.15
n=0.25
Time

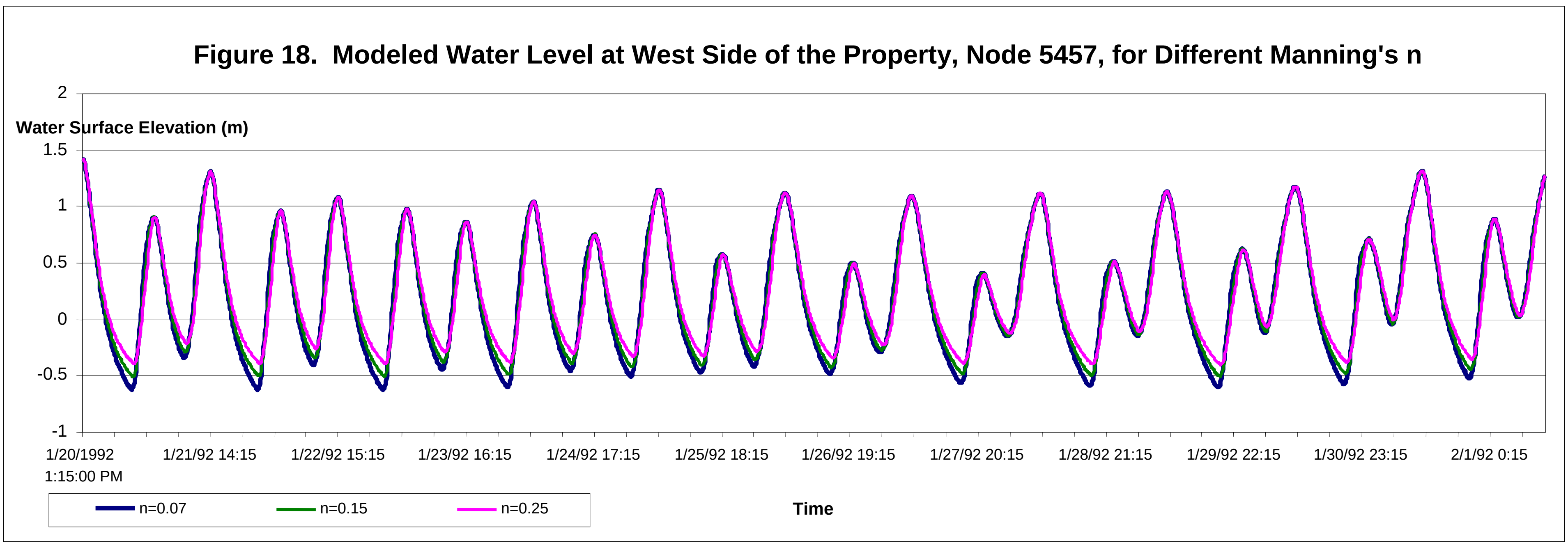


Figure 18. Modeled Water Level at West Side of the Property, Node 5457, for Different Manning's n
Water Surface Elevation (m)
2
1.5
1
0.5
0
-0.5
-1
1/20/1992 1:15:00 PM
1/21/92 14:15
1/22/92 15:15
1/23/92 16:15
1/24/92 17:15
1/25/92 18:15
1/26/92 19:15
1/27/92 20:15
1/28/92 21:15
1/29/92 22:15
1/30/92 23:15
2/1/92 0:15
n=0.07
n=0.15
n=0.25
Time

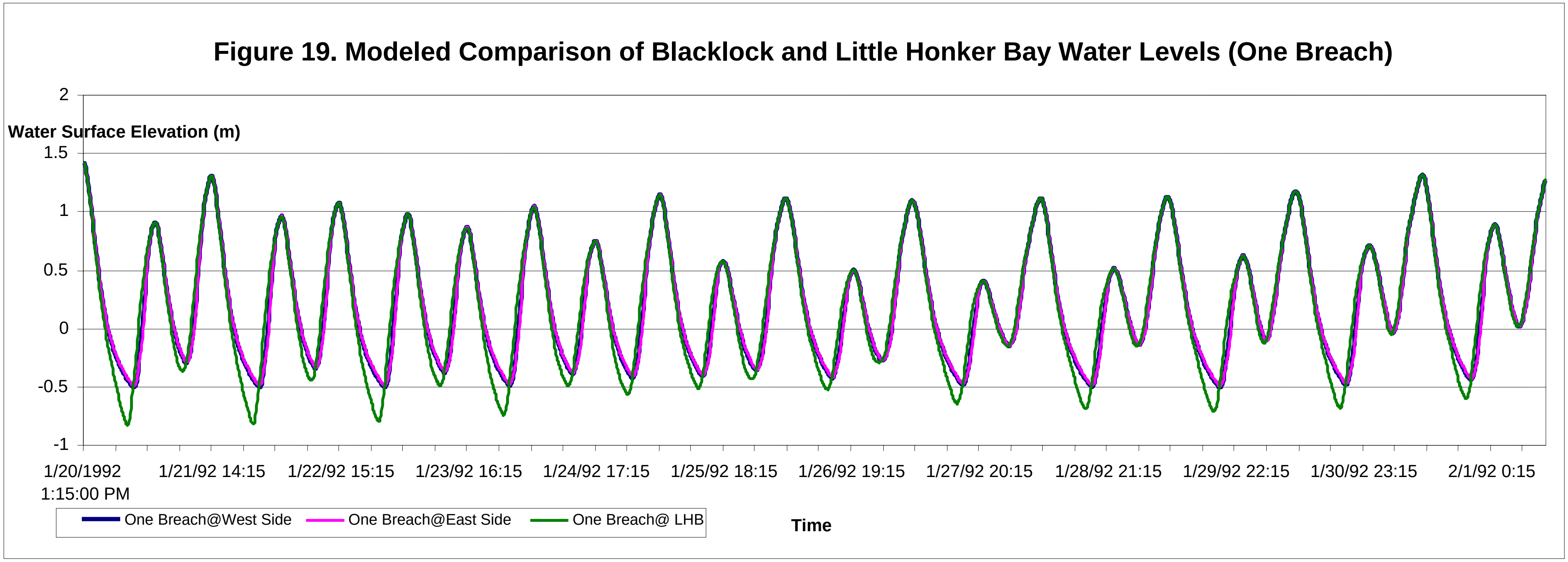


Figure 19. Modeled Comparison of Blacklock and Little Honker Bay Water Levels (One Breach)
Water Surface Elevation (m)
2
1.5
1
0.5
0
-0.5
-1
1/20/1992 1:15:00 PM
1/21/92 14:15
1/22/92 15:15
1/23/92 16:15
1/24/92 17:15
1/25/92 18:15
1/26/92 19:15
1/27/92 20:15
1/28/92 21:15
1/29/92 22:15
1/30/92 23:15
2/1/92 0:15
One Breach@West Side
One Breach@East Side
One Breach@ LHB
Time

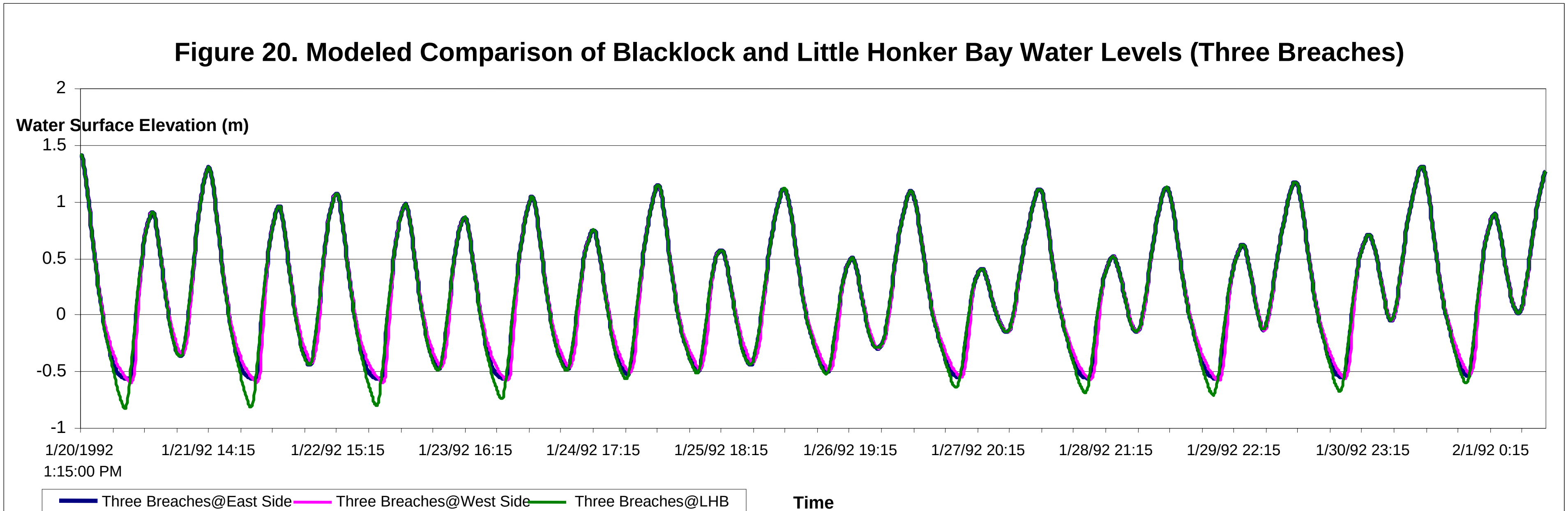


Figure 20. Modeled Comparison of Blacklock and Little Honker Bay Water Levels (Three Breaches)
Water Surface Elevation (m)
2
1.5
1
0.5
0
-0.5
-1
1/20/1992 1:15:00 PM
1/21/92 14:15
1/22/92 15:15
1/23/92 16:15
1/24/92 17:15
1/25/92 18:15
1/26/92 19:15
1/27/92 20:15
1/28/92 21:15
1/29/92 22:15
1/30/92 23:15
2/1/92 0:15
Three Breaches@East Side
Three Breaches@West Side
Three Breaches@LHB
Time

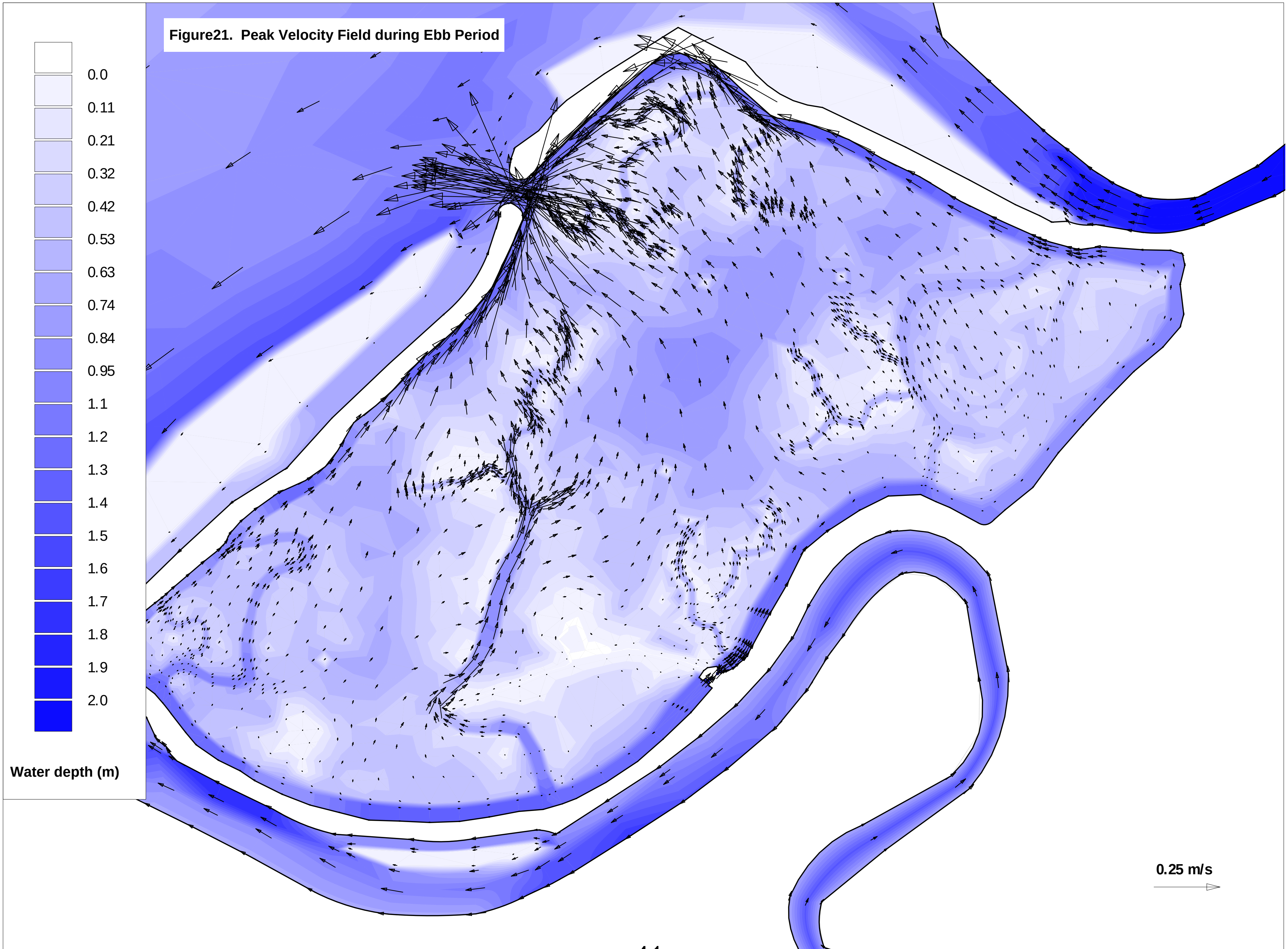


Figure21. Peak Velocity Field during Ebb Period
0.0
0.11
0.21
0.32
0.42
0.53
0.63
0.74
0.84
0.95
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
Water depth (m)
0.25 m/s

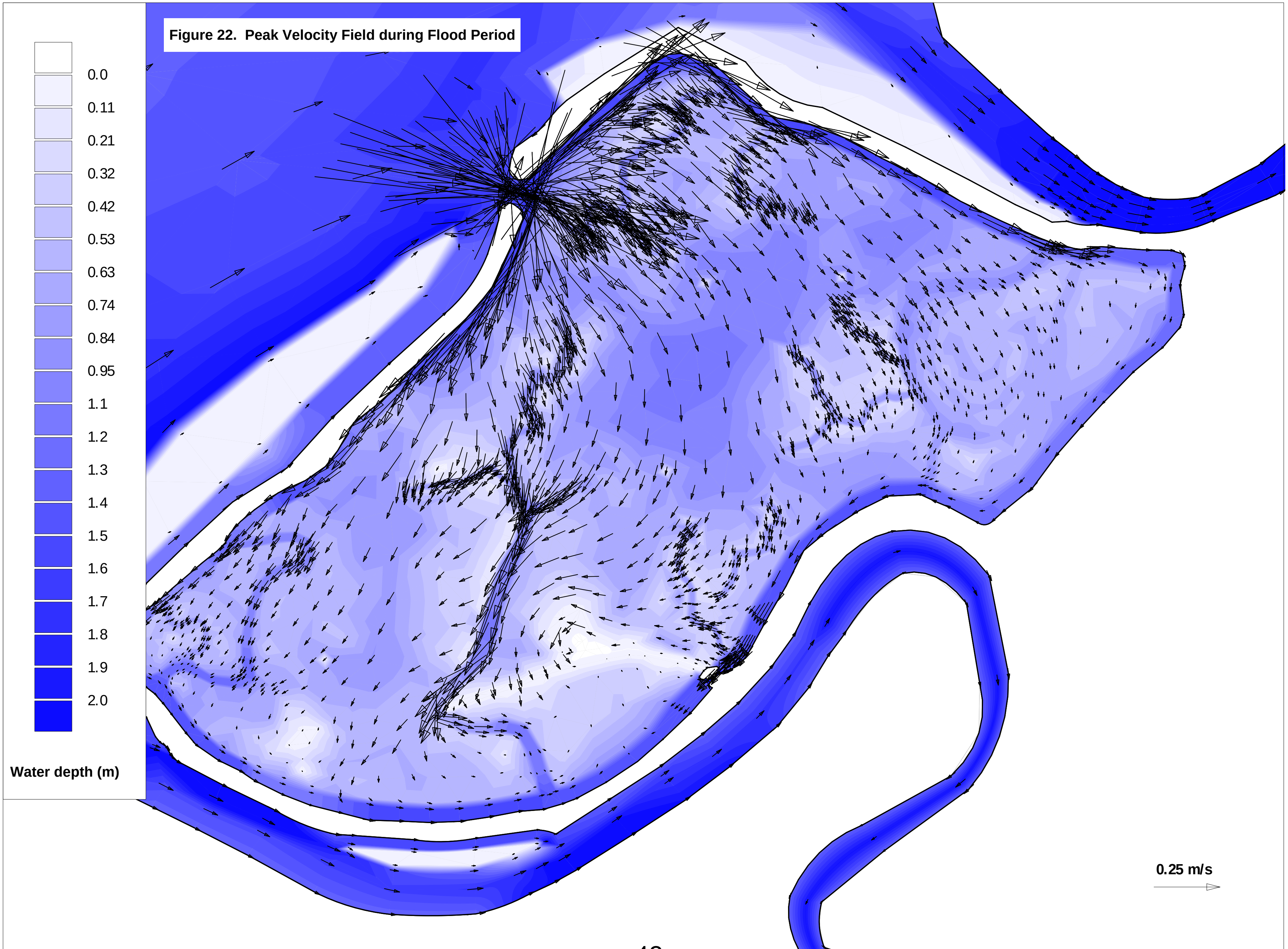


Figure 22. Peak Velocity Field during Flood Period
0.0
0.11
0.21
0.32
0.42
0.53
0.63
0.74
0.84
0.95
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2.0
Water depth (m)
0.25 m/s

5.0 MONITORING

This section describes the monitoring program that will accompany the Blacklock Restoration Project. The goals identified for this project include: 1) restoration of the Blacklock parcel and 2) avoidance of adverse impacts from construction and restoration activities. A detailed monitoring plan will be prepared as part of NEPA/CEQA compliance and permitting.

5.1 Restoration Performance Criteria

The performance criteria for the Blacklock Restoration are:

- High tide heights inside the site will be substantially similar to those observed outside the site, within two years following a planned or unintentional breach.
- Low tide heights inside the site will be no more than 1 foot greater than those observed outside the site, within two years following a planned or unintentional breach.
- Restored marsh plain elevations will continually trend upwards.
- Native tidal marsh species will colonize and establish at the site. Total percent cover shall be at least 50%. Species composition will be those species appropriate to the salinity regime and site elevations.

5.2 Restoration Outcome Monitoring

Monitoring will both document the expected beneficial effects of this project and detect potential impediments to successful marsh restoration as well as potential adverse outcomes. Monitoring for each of the performance criteria will continue until performance criteria are satisfied. If performance criteria are not met, the causes will be investigated and adaptive management actions/corrective measures will be implemented.

Monitoring components include:

1) Inundation regime
2) Levee breach geometry
3) Surface elevation changes/sedimentation
4) Slough network evolution
5) Native marsh vegetation development
6) Invasive plant species establishment
7) Water quality including production of methyl mercury
8) Nurse Slough monitoring network
9) Aquatic species utilization
10) Wildlife use

A schedule of restoration outcome monitoring is presented in Table 5.

Table 5 - Restoration Monitoring Schedule

Section	Description	Year(s) for Each Monitoring Activity 1	Frequency During Years Monitored	Seasonal Timing
5.2.1	Inundation regime	Years 1, 2, 3, 5, 10	Continuous	Spring Tides (Jun - Jul or Dec - Jan)
5.2.2	Levee breach and outboard marsh channel geometry[3]	Years 1, 2, 3, 5, 10	Annual	With air photo
5.2.3	Substrate development SET measurements	a) Years 1- 3 b) Year 4 to 25% native veg. cover	Semiannual Annual	winter, summer summer
		c) Begin at 25% native veg. cover, end at 75% native veg. cover	Once every 3 years	summer
	Substrate development Topographic Surveys	a) Years 1- 3 b) Year 4 to 25% native veg. cover	Semiannual Annual	winter, summer summer
		c) Begin at 25% native veg. cover, end at 75% native veg. cover	Once every 3 years	summer
5.2.4	Channel network evolution	Years 1, 2, 3, 5, 10	Annual	With air photo and topographic surveys
5.2.5	Calculate veg. percent cover from air photo and ground truthing	a) Year 1 to 35% native veg. cover	Annual	Jul - Aug
		b) Begin at 35% native veg. cover, end at 75% native veg. cover	triennial	Jul - Aug
	Vegetation field surveys (transects and plots)	Begin at 25% native veg. cover, end at 75% native veg. cover	triennial	Jul - Aug
5.2.6	Invasive plant species establishment	Year 1 to 75% native veg. cover	three times per year	spring, summer, fall
5.2.7	Water Quality in adjacent sloughs/LHB (hydrodynamics, sediment, chlorophyll)	Baseline sampling prior to breach Continue through inundation, end at stable results	Continuous	
	Water Quality In adjacent sloughs/LHB (hydrodynamics sediment, chlorophyll, methylmercury)	30 hour drifter studies	pre breach post breach	TBD
	Water Quality (methylmercury)	Baseline sampling prior to breach Begin at inundation	TBD[2]	
5.2.8	Fish Occurance	Begin year 2 after inundation	Annual	TBD
	Fish Site Function	Begin year 3 after inundation	Annual	TBD
5.2.9	Wildlife use (SMHM)	Begin at inundation on levees, survey available suitable habitat, end when stable survey results achieved	Annual	Jun - Aug
	Wildlife use (shorebirds & waterfowl)	Years 1, 3	Quarterly	Win, Spr, Sum, Fall
	Wildlife use (shorebirds & waterfowl)	Years 5, 10	annually	TBD

Notes
1. Projected time estimates to achieve Performance Criteria, actual duration is dependent upon Performance Criteria (see Restoration Performance Criteria, Section 5.1).
2. Sampling protocols to be developed by Mark Stephenson, CDFG

5.2.1 Inundation Regime

Inundation regime will be evaluated by collecting the tide stage both inside and outside the property. Evaluation of the tide stage data will inform SMPA ECAT agencies on whether the project is achieving unimpeded tidal exchange which is a fundamental component of the restoration objectives.

DWR maintains a water quality monitoring station (BLL) along Little Honker Bay/Little Honker Slough as part of the California Data Exchange Center (CDEC) monitoring network. This station measures precipitation, water temperature, wind speed and direction, atmospheric pressure and stage hourly. A pressure transducer was installed on the pond side of the levee to monitor tide stage within the site. Data is telemetered to Sacramento so tide stage can be monitored remotely. Comparing the tide stage inside the site with that of the slough will indicate whether the restoration is achieving unimpeded tidal flow. If tides are unimpeded, then the tide stage inside the site will be nearly identical to that which is measured in the adjacent slough. If tides are constricted, then the tide height inside the sit will be lower than outside; reduced height of high tides inside the site will provide a simple indicator of this problem. If low tides inside the site are higher than that of the adjacent slough, this indicates that the site does not drain effectively.

5.2.2 Levee Breach Geometry

Planned breaches would be designed for unimpeded tidal flow at the time of construction. If breaches are constructed as designed, the breaches may erode naturally in the early development stage then it may sediment in as the site's tidal prism decreases with overall sedimentation. Cross-sectional profiles would be conducted as soon as construction is complete.

With an unintended breach, natural erosion is also expected to occur until equilibrium conditions (stabilized breach size) are achieved. Evolution of an unplanned breach is dependent on the mechanism of the initial levee failure, the size and condition of the levee, and the levee material at the location of the unplanned breach. Cross sectional profiles will be conducted as soon as is practical after the breach occurs.

Periodic cross sectional profiles will be conducted of the breaches to document tidal scour or sedimentation and aid management decisions regarding breach maintenance. The timing of surveys will be dependent upon observed changes of the breach.

With an unintended levee failure, it will be imperative to evaluate breach geometry data closely in conjunction with tidal inundation data to assess if restoration goals are being achieved. If goals are not being achieved, adaptive management/corrective measures would likely include modifying the breach or breaching the levee in another location.

5.2.3 Surface Elevation Changes/Sedimentation

To meet the project goals of restoring tidal marsh, sedimentation must occur within the subsided Blacklock property. Naturally deposited sediment aided by accumulation of plant detritus forms the substrate that is essential to plant establishment and growth and it provides the environment required by benthic organisms. One of the proposed breach locations was selected in part because of its proximity to Little Honker Bay. It is expected that Little Honker Bay will provide a sediment source for the Blacklock restoration site.

Baseline sediment concentrations were monitored in both Little Honker Bay and Arnold Slough using optical backscatter (OBS) instrumentation. This data collection effort conducted by San Francisco State University (Snow, in press) concluded that:

1) There are temporal differences in suspended sediment concentrations and that the most significant differences are seen at the seasonal level.
2) The highest concentrations are seen in the summer time and can be attributed to re-suspension of sediment by wind (Cuetara, et al. 2001). The second highest levels are in winter and are related to runoff from the rainy season.
3) The leveling off of the sediment concentrations in the early spring may represent when sediment supply from runoff is exhausted and the following increase in late spring, early summer represents a transition to a new source of sediment.
4) No obvious relationship was evident between monthly tidal variations and sediment concentrations.
5) There is a tidal relationship between water level and sediment concentration. On the rising limb of the tide the suspended sediment concentrations also rise and on the falling limb of the tide the sediment concentrations lower.

At the request of DWR modelers, the OBS in Little Honker Bay will remain in place for an additional six months to collect additional data for the sediment transport model. This instrument was removed in May 2006.

Sediment accumulation on the site will be monitored with Sediment Erosion Tables (SET's) installed and periodic topographic surveys. The topographic surveys, at fixed locations will be conducted periodically to assess elevation changes.

Three SET's have been installed throughout the site as shown on Figure 5. The SET's were placed in three distinct habitat types throughout the site. One was placed within emergent vegetation in the southwest area of the parcel, a second was placed in an existing pond, and the third placed in a slightly higher area within a large area of salt grass, near the northeast corner of the parcel.

Vertical accretion of sediments will be measured and compared with baseline data that was collected prior to the breach. The SET (Calhoun et al, 2002) consists of an arm temporarily inserted into a survey rod secured in a concrete filled PVC pipe. Pins are then inserted through a plate on the arm and successive measurements track changes in marsh surface elevation relative to the base of the pipe. A sampling structure was constructed at each SET location prior to inundation to prevent disturbance of the surface where measurements are made. To account for possible settlement of the SETs themselves, which may occur because the weight of the concrete used to install them could cause them to sink in the soft peat soils, the benchmark on each SET will be surveyed to a known nearby benchmark at each SET measurement event.

In addition to SET measurements, feldspar marker horizons were installed at each SET and cryogenic core samples will be extracted from the feldspar locations. Data from the SET and feldspar marker horizons together allow for direct measurements of sediment accretion at the site.

5.2.4 Slough Network Evolution

To support the diverse fish and wildlife communities expected to use the restored tidal marsh, a slough channel network must be maintained or created. In addition, an effective slough network is necessary to maintain the hydrology on site and support tidal exchange throughout the property.

While there is an existing slough network on the site, the location of the breach may result in flows altering the configuration of sloughs within the property and these sloughs are all many feet below marsh pain elevations. Changes in the slough network will be monitored using aerial photography. Parameters to be measured include total surface area of channels, areas of expansion and loss, and changes over time. Aerial data will be supplemented with topographic cross-sections of selected areas. This data is essential for calibration and verification of the computer model.

5.2.5 Native Marsh Vegetation Development

Vegetation development will be monitoring annually to assess if native tidal marsh vegetation develops consistent with the performance criteria developed for this project. Plant community evolution will be measured as percentage change in aerial extent as well as conformity with local native plant diversity found in the region.

While there is extensive native marsh vegetation currently on the site, it is expected that some of that will die off during tidal inundation. Some emergent species will likely survive inundation and continue to colonize throughout the site. The die off of vegetation as a result of inundation will provide material for substrate formation.

Vegetation monitoring will consist of digital and field examination of ortho-rectified aerial photos. Evolution will be measured as a change in percent cover and species over time. Species composition will be monitored and changes noted, using the classification system established by DFG.

Aerial photos will be shot in June or July to correspond with the aerial surveys conducted as part of the Suisun Marsh Vegetation Survey (DFG, 1999 and 2003) Survey methodology established for the Suisun Marsh Vegetation Survey will be implemented.

Additional information about tidal marsh development and functions may be informed by establishing permanent transects and plots after marsh development occurs and vegetation colonizes the site.

5.2.6 Control of Invasive Plant Species

Colonization of the Blacklock restoration site by non-native invasive plant species would jeopardize meeting the objectives of the restoration. Many of the important ecological benefits of restored tidal marsh vegetation will not be provided by invasive species. Specifically, colonization by invasive non-native plant species may prevent establishment of native tidal marsh vegetation.

Monitoring and control of non-native invasive plant species will focus on two invasive plants that are particularly problematic in Suisun-*Phragmites australis* and perennial pepperweed (*Lepidium latifolum*). Lepidium is a problem throughout Suisun marsh, however, it has not been found at Blacklock to date. When and if pepperweed is found on the site, control methods, including herbicide use, will be employed to prevent its establishment at the site. DWR staff will consult with weed management specialists to identify the most appropriate control method.

Annual surveys for non-native invasive plant species will be conducted. In addition, field personnel will be encouraged to report any occurrences of pepperweed to weed control specialists for immediate treatment, if appropriate.

The spread of phragmites is a problem throughout Suisun Marsh and control experiments are ongoing. As in other managed wetlands, populations of phragmites have become established at Blacklock. The depth and duration of flooding with tidal inundation may help control the spread of this species (FWS, 1989). Monitoring will be conducted annually to determine any changes in phragmites cover. Alternative treatment techniques will be employed to control the spread of this species, if needed.

5.2.7 Water Quality including production of Methyl Mercury

Water quality changes, specifically changes in salinity and the production of methyl mercury, resulting from tidal inundation at Blacklock are of particular interest to DWR and other agencies involved in long term planning decisions in Suisun Marsh.

Hydrodynamic modeling conducted by DWR has suggested that breaching levees in Suisun has an effect on salinities both in Suisun Marsh and in the Sacramento San Joaquin Delta. The specific effects are dependent on the size and location of the breach and the area of inundation. Modeling of the Blacklock restoration shows changes in salinity in Montezuma Slough, both upstream and downstream of Nurse Slough. These changes were minor and are not expected to impact DWR's ability to meet SWRCB salinity standards for Suisun Marsh. DWR will continue to collect salinity data at the BLL monitoring station adjacent to the restoration. Dissolved oxygen, temperature, and EC will be collected within the restoration site as part of the fish monitoring program.

Wetlands are known to be areas of high methyl mercury production (Heim et al 2003, Davis et al 2003, Weiner et al 2003, Marvin De-Pasquale et al 2003). The factors that influence methyl mercury production are numerous and not well understood. However, there are three key factors that appear to be critical to net methyl mercury production. These factors include total mercury concentration, speciation of the mercury, and level of activity of methylating bacteria. Intertidal vegetated wetlands have been found to have significantly greater potential to methylate mercury than adjacent channels, mudflats, or open water (Marvin-DiPasquale et al 2003). While tidal wetland areas in Suisun Marsh and the Delta have been shown to be high producers of methyl mercury, production of methyl mercury in the managed seasonal marshes has not been well documented; limited sampling (Schroeter and Moyle, unpublished data, working with DFG) suggest in some instances that high methyl mercury concentrations can occur in managed wetlands discharges at times when that discharge water experiences low dissolved oxygen levels. Mark Stephenson, DFG Moss Landing is investigating methyl mercury issues in Suisun Marsh as part of a CALFED funded study. As part of comprehensive water quality sampling program described below in section 5.2.7.1, DFG is developing specific study protocol for investigating methyl mercury exports and Methyl mercury in sediments at Blacklock. Pre-project methyl mercury samples were collected in January 2004 following levee overtopping.

5.2.7.1 Nurse Slough Monitoring Network

DWR, DFG, and USGS are collaborating on an interdisciplinary study to observe physical and chemical response to a planned levee breach at the project site. This study represents a rare opportunity to study the before and after effects of a step change in geometry of a wetland slough complex. The study focuses on hydrodynamics, sediment, chlorophyll, and methylmercury dynamics of Nurse/Denverton Slough and the 70 acre Blacklock property. Instrumentation was deployed in February 2006 that is sufficient to characterize changes in water, sediment, chlorophyll, methylmercury and salt flux and residence time that may arise due to a Blacklock levee breach. Other likely collaborations in the planning stages prior to levee breach are related to dissolved oxygen dynamics, secondary production, fish usage, and toxics in invertebrate biomass. The study also complements concurrent analysis of Blacklock sediment and plant biomass accretion potential. Given existing plans for large-scale tidal restoration in Suisun Marsh, the experiment design offers the potential for significant elucidation of the impact of diked wetland tidal marsh restoration in the Nurse Slough complex, Suisun Marsh, and the larger San Francisco estuary.

Brief conceptual models and experiment questions

1. <u>Hydrodynamics and transport:</u> After the Blacklock levee breaches, the tidal prism of the Nurse Slough complex will increase by nearly the tidal prism volume of the property (approximately 160 acre-feet). This volume is approximately 4% of the tidal prism at the mouth of Nurse Slough. In situ ADCP's will detect this step change in the tidal flow regime. The 70 acre property will also induce a small tidal current asymmetry in

the timing between breach current and Little Honker Bay current. Preliminary modeling results suggest that flood tide velocity through a small levee breach would likely be relatively higher but shorter duration than ebb tide flows. This will result in some tidal salt trapping that will tend to mix the strong salinity gradient between Beldons Landing (on Montezuma Slough) Denverton Slough at Blacklock. A compression of the regional tidal datum from frictional energy dissipation on the relatively shallow property is expect as well as some modification of water residence time along the Nurse/Denverton Slough complex. Finally, since Nurse and Denverton Sloughs converge in a loop, the location of the tidal convergence may be induced to move in some unknown way.

Experimental questions include:

- How does nurse Slough residence time change at the tidal and spring-neap timescale due to the addition of Blacklock tidal prism?
- How much is regional salinity and tidal range affected by the additional tidal prism and change in current phasing?

Denverton Creek inflows and the position of the Nurse Slough mouth along the east-west salinity gradient of Montezuma Slough would tend to maintain the salinity gradient along Nurse and Denverton Slough. Given the nominal depth of the lower Nurse Slough reach (~30 ft), we would expect to observe at least periodic gravitational circulation. Addition of Blacklock hydrodynamics after levee breach could change the frequency and strength of density driven current dynamics with concomitant effects on sediment transport and sediment associated mercury transport.

Experimental questions include:

- Will the tidal prism of Blacklock be sufficient to mix the salinity gradient in Nurse Slough and change the characteristics of periodic gravitational circulation between lower Nurse Slough and Beldons Landing?

2. <u>Sediment transport:</u> After levee breach, Blacklock will accumulate local sediment due to elevated suspended sediment concentration in Little Honker Bay and the velocity asymmetry at the breach site. We will observe higher velocity, shorter duration flow (jet flow) on the flood tide that transports Little Honker Bay sediment into Blacklock. Ebb tide flows will be longer in duration, and exhibit lower velocities (potential flow). Therefore, some of the sediment that enters on the flood tide through the breach will settle out and/or be trapped by marsh plants. It is expected that a transient period when sediment flux will be significantly negative at the mouth of Nurse Slough will occur while Blacklock is accumulating sediment and Little Honker Bay is eroding in the region of the breach.

Experimental questions include:

- Will the ebb-flood velocity asymmetry at the levee breach erode and trap sediment from Little Honker Bay?
- Will there be enough energy in the levee breach to distribute sediment widely inside the Blacklock property to raise land elevation?

3. <u>Methylmercury:</u> Methylmercury is produced in low oxygen environments in the presence of sulfate reducing bacteria (like marshes). Elemental mercury likely accumulated with hydraulic mining debris on Blacklock in the late 1800s. The property was subsequently diked, partially encapsulating mercury on the site. Opening the site to tidal action will change mercury methylation dynamics. We assume that there will be a net export of the mercury stored in near-surface sediments at Blacklock. There could be a spike in methylmercury export for an unknown period that reduces asymptotically as time passes. Once in the open channel, methylated mercury may be further transformed (perhaps demethylated) due to the different light,

temperature, oxygen, and other chemical conditions. We will observe these transformations at the mouth of Nurse Slough.

Several instruments have been deployed in the Nurse Slough/Little Honker Bay area. Three permanent multi-parameter stations (water level, temperature, salinity, plus one with meteorology) were deployed to monitor the salinity gradient along Montezuma and Nurse Slough. Nearby permanent stations exist at Beldons Landing, Montezuma Slough near the salinity control gate, and adjacent to the property on Denverton Slough. Doppler current profilers and multi-parameter water quality instruments were deployed in January 2005 in the mouth of Nurse Slough, the western branch of Nurse Slough, and Denverton Slough along the northern edge of the Blacklock property. An additional Doppler current profiler and multi-parameter instrument were deployed on May 1, 2005 at the mouth to improve flux estimates. The deployment will be maintained for at least one year to capture tidal, fortnight, and seasonal constituent flux dynamics. These instruments will be sufficient to measure water, sediment, methylmercury, chlorophyll, temperature, dissolved oxygen, and salt fluxes. We will observe all parameters for approximately six months prior to levee breach, then observe changes in these quantities after the levee breach (approximately September 2006). Nurse Slough and Denverton Slough come together north of Bradmoor Island forming a loop. Doppler current profilers and multi-parameter sondes deployed on the Nurse Slough and Denverton Slough branches will capture the dynamics of the hydrodynamic/transport convergence.

One multi-parameter sonde will be deployed inside the Blacklock property (as near to the levee breaches possible) to measure the suspended sediment concentration, chlorophyll, and salinity and thus establish gradients in those quantities between Blacklock property and Little Honker Bay. Sediment flux will be estimated by measuring sediment concentration in Little Honker Bay near the breach, and estimating tidal flows with water level observations and estimates of change in storage. Sediment flux estimates through the breach will be used in conjunction with measured sediment accumulation on existing sediment erosion tables to estimate long-term spatial and temporal accumulation of sediment at Blacklock. The internal sonde will also log chlorophyll fluorescence for comparison to the same quantity at the mouth of nurse Slough to deduce Blacklock's contribution to the phytoplankton budget.

Two 30-hour studies will be conducted to intensively measure currents, sediment transport, chlorophyll, and methylmercury at key locations in the Nurse Slough complex. This effort serves to calibrate in situ instruments, generate high-resolution suspended sediment dynamics (from ADCP acoustic backscatter intensity), pinpoint hydrodynamic exchange dynamics between Nurse Slough and Montezuma Slough, and give us a reason to stay up all night. Passive drifters will be released in such a way as to measure tidal excursion distance and ultimately deduce water residence time as a function of position along Nurse Slough.

This effort offers a reasonable opportunity to expand the knowledge base on several important issues. It is expected that peer-reviewed papers will be prepared on the following topics:

1. Methylmercury production from breaching levees on formerly diked wetlands.
2. Chlorophyll production and quality both on the Blacklock site, and downstream at the mouth of Nurse Slough.
3. The salinity mixing impact of levee breaches.
4. Residence time and the spatial/temporal contribution of slough complexes to the estuarine food web.
5. Sediment accumulation on formerly diked and subsided wetlands.

5.2.8 Fish

Desired outcomes of the restoration of Blacklock to tidal marsh are to provide habitat for native fishes and aid in the recovery of listed fish species in Suisun Marsh. In a review of information regarding native fish use of restored freshwater tidal wetlands, Brown (2003) concluded that restoring tidal wetlands my not provide as great a benefit to native fish populations as originally expected. Studies of tidal marsh restoration sites in the Delta have found statistically higher density of native fish at reference sites as compared to the restored sites (Simensted et al. 2000). This suggests that the restored sites do not provide the same habitat value as the historic tidal wetland. Similar studies conducted for BREACH at sites in Suisun Marsh do indicate potential for native fishes benefits (Simenstad, unpublished data). Further, Dr. Peter Moyle of UC Davis, who has conducted more than 25 years of fish monitoring in Suisun Marsh, has stated his belief that tidal marsh restoration in Suisun Marsh could provide important benefits to native fishes (CALFED Science Conference, 2004). It is likely that native fish would benefit from tidal marsh restoration as has been demonstrated in other areas (Miller and Simenstad 1997, Miller and Sadro 2003, Schreffler et al 1990, Simensted et al. 1993).

Following breaching of the site it will take several decades for the restored wetland to develop and mature. During this period the marsh will shift from allochthonous (outside) to autochthonous (within) biotic production. This shift will affect the ability of the habitat to provide adequate food-chain support. The goal of the fisheries monitoring is to assess the change in habitat value of the Blacklock restoration site to native fishes over time. Specific questions to be addressed include:

- Is there a difference in fish assemblage at the restored and reference sites?
- Does the fish assemblage (species type and abundance) vary with habitat type?
- How do fish support functions (phytoplankton production, invertebrate composition and abundance, vegetation, tidal hydrology, etc.) vary between the restored and reference sites?

Monitoring will document both site progression from year to year and site function during 'checkpoint' years. Monitoring will begin two years after the initial levee breach. This will allow time for the site to adjust to the changed conditions and begin the shift from external to internal production. Monitoring of fish occurrence and abundance will begin in year two and continue on a yearly basis as shown in Table 6. Monitoring of site function will begin in year three and continue on a triennial basis (Table 6). This monitoring will include an assessment of fish diet and growth rates. Monitoring for fish habitat function is critical as monitoring fish occurrence and abundance exclusively can provide misleading information on the progress of the restoration project (Callaway 2001). Monitoring frequency and duration will be determined by available funding.

5.2.9 Wildlife

DWR anticipates that restoration of Blacklock to tidal marsh will provide long-term ecological benefits to tidally dependent wildlife species. After tidal inundation, it is expected that habitat will be available for waterfowl and shorebirds. However, it is anticipated to take several years of sediment accretion for marsh elevations to raise enough to provide habitat for terrestrial species. Once surface elevations rise, and vegetation colonizes, it is expected that Blacklock will develop into a fully functioning tidal marsh with suitable habitat for marsh dependent wildlife species, including black rails and salt marsh harvest mice. As sedimentation rates slow with increasing elevations and the site is bordered entirely by steep levee, high marsh dependent species such as the black rail and SMHM may require many years before extensive suitable habitats develop at Blacklock.

DWR and/or DFG will monitor waterfowl and shorebird uses of the Blacklock restoration using standard protocols (Point Reyes Bird Observatory protocols for monitoring birds in tidal marsh as described in Nur 2005). These surveys will begin within one year of breaching and will continue quarterly at both low and high tide to track shorebird and waterfowl use of the ponds. Non threatened and endangered bird species monitoring will end five years after breaching.

Black rail have also been detected on site, under its current management regime. Black rail require well-vegetated high-marsh and marsh-upland transition zones. Therefore, it is expected to take several years for this habitat to establish at the Blacklock restoration site. Monitoring for black rails will take place as part of the waterfowl and shorebird surveys. If rails are detected, additional surveys can be scheduled. Other targeted wildlife species include Suisun song sparrow (*Melospiza melodia maxillaris*), marsh wren (*Cistothorus palustris*), common yellowthroat (*Geothlypis trichas*) and other avian species.

After tidal inundation, SMHM trapping at Blacklock will be conducted annually, on any available habitat and will continue as habitat develops on the site. SMHM surveys will continue until populations are stable. Just prior to the levee breach (constructed), the breach locations will be surveyed following USFWS protocol. Immediately post-breach, traps will be set in all available un-inundated areas (which may only be the levee) to capture rodents as they leave the site. These traps will be set for approximately two weeks to assess movements and residence times of rodents in the un-inundated areas.   Trapping protocol will be similar to protocol used by DWR and DFG in their existing marsh wide SMHM surveys.

Table 6 Post Breach Fish Monitoring Schedule

	Annually beginning year 2												Triennally beginning year 3											
Description	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
On-Site Restoration Monitoring																								
Fish occurrence and abundance			M	M	M	M	m	m	m						M	M	M	M	m	m	m			
Fish diet																M	M		m					
Fish growth rate																M	M		m					
Invertebrate density and diversity																M	M		m					
Off-Site Reference Site Monitoring																								
Fish occurrence and abundance															M	M	M	M	m	m	m			
Fish diet																M	M		M					
Fish growth rate																M	M		m					
Invertebrate density and diversity																M	M		m					

M = sample once per month

m = omit if funds are insufficient

6.0 FINAL DESIGN AND IMPLEMENTATION ACTIVITES

This section describes the remaining tasks that will need to be completed to support the final design and implementation activities. The schedule for completion of the Blacklock restoration project is presented in Table 7. This schedule is preliminary and subject to change. Factors that may affect the schedule include whether an unintended levee breach occurs prior to completion of the plan and implementation of the planned breach, delays in permit acquisition, funding, and availability of staff resources.

Table 7- Preliminary implementation schedule-

April-06	Complete Restoration Plan
May-06	Complete Detailed Monitoring Plan including cost estimates
May-06	Complete Review of Draft Restoration Plan (CDBA, Blacklock Advisory Team
Spring 2006	Complete CEQA documentation.
Spring 2006	Prepare Environmental Permits/ ESA consultations
Sping/Summer 2006	Endangered Species Consultation
September-06	Complete Environmental Permitting (Final Restoration Plan) and NEPA compliance
September-06	Breach Levee
October-06	Begin post-implementation restoration monitoring

6.1 NEPA/CEQA compliance

DWR, with cooperation with the SMPA ECAT agencies, will prepare a joint Environmental Assessment/Initial Study to evaluate and assess the environmental impacts of this project. If appropriate, a Draft Negative Declaration (or Mitigated Negative Declaration) will be filed with the Governors office of Planning and Research and a Finding of No Significant Impact will be submitted to the federal register for review. DWR is the CEQA lead for this project. USBR is the NEPA lead.

6.2 Environmental Permitting

The following regulatory requirements apply to this project:

- San Francisco Bay Conservation and Development Commission
- Clean Water Act Section 404 Nationwide Permit 27 (US Army Corps of Engineers)
- Section 401 Water Quality Certification (RWQCB)
- Section 7 Endangered Species Act
- California Endangered Species Act

6.3 Monitoring Plan

DWR, in coordination with the Project Work Team participants, will prepare a detailed monitoring plan. This plan will include detailed description of post breach aquatic, vegetation, wildlife, avian, sediment and water quality monitoring. The Monitoring Plan will follow the December 20, 2004 USACE Mitigation and Monitoring Guidelines, as appropriate.

6.4 Final Restoration Plan

Following application for permits and incorporation of any changes based on comments during the permitting, a final restoration plan will be prepared. The Final Plan will identify the design to be constructed.

6.5 Construction plans and specifications

Following completion of permitting and the Final Restoration Plan, construction plans and specifications will be prepared suitable for field implementation by a contractor.

6.6 Construction

Construction will take place between June 1 and September 30 to correspond with the Suisun Marsh construction and maintenance season, as recommended by BCDC and specified by USACE RGP 24215N (or subsequent permit) and described in the Suisun Marsh Management Program.

Monitoring will commence after construction occurs, as detailed in the post-implementation monitoring plan (described above).

6.7 Funding

Additional funding will be required to implement a post-implementation monitoring program.

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APPENDIX A

Blacklock Restoration Project Work Team

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Steven Chappell	SRCD	ECAT, interim management, maintenance
Chris Enright	Ca DWR	Hydrodynamics, sediment transport
Cassandra Enos	Ca DWR	ECAT, Fisheries, Interim Management
Terri Gaines	Ca DWR	Project management, plan devel, permitting, etc.
Jeff Hart	Hart Restoration	Revegetation, brush boxes
James Kulpa	WWR	Surveying, SET
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Jim Long	Ca DWR	Fisheries
Aaron Miller	Ca DWR	modeling
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Laura Patterson	Ca DWR	Wildlife, SMHM
Patty Quickert	Ca DWR	ECAT Wildlife, SMHM trapping
John Robles	USBR	ECAT, NEPA
Eliza Sater	formerly Ca DWR	Fisheries
Leonard Sklar	SFSU	Sediment availability and transport
Randall Smith	Ca DWR	Surveying
Mark Stephenson	Ca DFG	methyl mercury
Jim Sung	Ca DWR	Levee maintenance, design, repair
Mary Snow	SFSU	Sediment availability
Gina VanKlompenburg	Ca DFG	ECAT Suisun Marsh restoration planning
Bruce Wickland	SRCD	Interim management, maintenance
Jean Witzman	Ca DWR	Vegetation, invasive species control
Xiaochun Wang	Ca DWR	Modeling

APPENDIX B

Blacklock Restoration Advisory Team

Project Manager
Terri Gaines
Staff Environmental Scientist
California Department of Water Resources

Science Advisor
Dr. Stuart Siegel
Wetlands Ecologist
Wetlands and Water Resources

Hydrodynamic Modeling, Water Quality, Sediment Transport
Christopher Enright
Senior Engineer
California Department of Water Resources

Sediment Availability and Transport
Dr. Leonard Sklar
Professor of Geoscience
San Francisco State University

Wetland Ecology, Soils
Dr. Steve Culberson
Staff Environmental Scientist
(formerly DWR)
CBDA Science Program

Fisheries, Interim Management
Cassandra Enos
Staff Environmental Scientist
California Department of Water Resources

Interim Management Advisor, Levee Maintenance
Steven Chappell
Executive Director
Suisun Resource Conservation District

Wildlife
Laurie Briden
Wildlife Biologist
California Department of Fish and Game

NEPA, permitting
John Robles
Environmental Specialist
U.S. Bureau of Reclamation

Wildlife, Fisheries, ESA
Cecilia Brown
Biologist
U.S. Fish and Wildlife Service

APPENDIX C

U.S. Fish and Wildlife Service Species List
Document # 060330024152

United States Department of the Interior

FISH AND WILDLIFE SERVICE

Sacramento Fish and Wildlife Office
2800 Cottage Way, Room W-2605
Sacramento, California 95825

March 30, 2006

Document Number: 060330024944

Terri Gaines
Ca Department of Water Resources
3251 S Street
Sacramento, Ca 95816

Subject: Species List for Blacklock Restoration Project

Dear: Ms. Terri Gaines

We are sending this official species list in response to your March 30, 2006 request for information about endangered and threatened species. The list covers the California counties and/or U.S. Geological Survey 7½ minute quad or quads you requested.

Our database was developed primarily to assist Federal agencies that are consulting with us. Therefore, our lists include all of the sensitive species that have been found in a certain area *and also ones that may be affected by projects in the area*. For example, a fish may be on the list for a quad if it lives somewhere downstream from that quad. Birds are included even if they only migrate through an area. In other words, we include all of the species we want people to consider when they do something that affects the environment.

Please read Important Information About Your Species List (below). It explains how we made the list and describes your responsibilities under the Endangered Species Act.

Our database is constantly updated as species are proposed, listed and delisted. If you address proposed and candidate species in your planning, this should not be a problem. However, we recommend that you get an updated list every 90 days. That would be June 28, 2006.

Please contact us if your project may affect endangered or threatened species or if you have any questions about the attached list or your responsibilities under the Endangered Species Act. A list of Endangered Species Program contacts can be found at www.fws.gov/sacramento/es/branches.htm.

Endangered Species Division

TAKE PRIDE IN AMERICA

Sacramento Fish & Wildlife Office

Federal Endangered and Threatened Species
that Occur in or may be Affected by Projects in the
DENVERTON (481B)
U.S.G.S. 7 1/2 Minute Quad
Database Last Updated: March 1, 2006
Document Number: 060330024152

Listed Species

Invertebrates

Branchinecta conservatio - Conservancy fairy shrimp (E)
Branchinecta conservatio - Critical habitat, Conservancy fairy shrimp (X)
Branchinecta lynchi - Critical habitat, vernal pool fairy shrimp (X)
Branchinecta lynchi - vernal pool fairy shrimp (T)
Desmocerus californicus dimorphus - valley elderberry longhorn beetle (T)
Elaphrus viridis - Critical habitat, delta green ground beetle (X)
Elaphrus viridis - delta green ground beetle (T)
Lepidurus packardi - Critical habitat, vernal pool tadpole shrimp (X)
Lepidurus packardi - vernal pool tadpole shrimp (E)

Fish

Hypomesus transpacificus - Critical habitat, delta smelt (X)
Hypomesus transpacificus - delta smelt (T)
Oncorhynchus mykiss - Central Valley steelhead (T)
Oncorhynchus tshawytscha - Central Valley spring-run chinook salmon (T)
Oncorhynchus tshawytscha - winter-run chinook salmon, Sacramento River (E)

Amphibians

Ambystoma californiense - California tiger salamander, central pppulation (T)
Rana aurora draytonii - California red-legged frog (T)

Reptiles

Thamnophis gigas - giant garter snake (T)

Birds

Haliaeetus leucocephalus - bald eagle (T)
Rallus longirostris obsoletus - California clapper rail (E)

Mammals

Reithrodontomys raviventris - salt marsh harvest mouse (E)

Plants

Cordylanthus mollis ssp. mollis - soft bird's-beak (E)
Lasthenia conjugens - Contra Costa goldfields (E)
Lasthenia conjugens - Critical habitat, Contra Costa goldfields (X)

Candidate Species

Fish

Oncorhynchus tshawytscha - Central Valley fall/late fall-run chinook salmon (C)

Oncorhynchus tshawytscha - Critical habitat, Central Valley fall/late fall-run chinook (C)

Key:

(E) *Endangered* - Listed (in the Federal Register) as being in danger of extinction.
(T) *Threatened* - Listed as likely to become endangered within the foreseeable future.
(P) *Proposed* - Officially proposed (in the Federal Register) for listing as endangered or threatened.
(NMFS) Species under the Jurisdiction of the National Marine Fisheries Service. Consult with them directly about these species.
Critical Habitat - Area essential to the conservation of a species.
(PX) *Proposed Critical Habitat* - The species is already listed. Critical habitat is being proposed for it.
(C) *Candidate* - Candidate to become a proposed species.
(X) *Critical Habitat* designated for this species

Important Information About Your Species List

How We Make Species Lists

We store information about endangered and threatened species lists by U.S. Geological Survey 7½ minute quads. The United States is divided into these quads, which are about the size of San Francisco.

The animals on your species list are ones that occur within, or may be affected by projects within, the quads covered by the list.

- Fish and other aquatic species appear on your list if they are in the same watershed as your quad or if water use in your quad might affect them.
- Birds are shown regardless of whether they are resident or migratory. Relevant birds on the county list should be considered regard-less of whether they appear on a quad list.

Plants

Any plants on your list are ones that have actually been observed in the quad or quads covered by the list. Plants may exist in an area without ever having been detected there. You can find out what's in the nine surrounding quads through the California Native Plant Society's online Inventory of Rare and Endangered Plants.

Surveying

Some of the species on your list may not be affected by your project. A trained biologist or botanist, familiar with the habitat requirements of the species on your list, should determine whether they or habitats suitable for them may be affected by your project. We recommend that your surveys include any proposed and candidate species on your list.

For plant surveys, we recommend using the Guidelines for Conducting and Reporting Botanical Inventories. The results of your surveys should be published in any environmental documents prepared for your project.

Your Responsibilities Under the Endangered Species Act

All plants and animals identified as listed above are fully protected under the Endangered Species Act of 1973, as amended. Section 9 of the Act and its implementing regulations prohibit the take of a federally listed wildlife species. Take is defined by the Act as "to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect" any such animal.

> Take may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or shelter (50 CFR §17.3).

Take incidental to an otherwise lawful activity may be authorized by one of two procedures:

- If a Federal agency is involved with the permitting, funding, or carrying out of a project that may result in take, then that agency must engage in a formal consultation with the Service.

  During formal consultation, the Federal agency, the applicant and the Service work together to avoid or minimize the impact on listed species and their habitat. Such consultation would result in a biological opinion by the Service addressing the anticipated effect of the project on listed and proposed species. The opinion may authorize a limited level of incidental take.

- If no Federal agency is involved with the project, and federally listed species may be taken as part of the project, then you, the applicant, should apply for an incidental take permit. The Service may issue such a permit if you submit a satisfactory conservation plan for the species that would be affected by your project.

  Should your survey determine that federally listed or proposed species occur in the area and are likely to be affected by the project, we recommend that you work with this office and the California Department of Fish and Game to develop a plan that minimizes the project's direct and indirect impacts to listed species and compen-sates for project-related loss of habitat. You should include the plan in any environmental documents you file.

Critical Habitat

When a species is listed as endangered or threatened, areas of habitat considered essential to its conservation may be designated as critical habitat. These areas may require special management considerations or protection. They provide needed space for growth and normal behavior; food, water, air, light, other nutritional or physiological requirements; cover or shelter; and sites for breeding, reproduction, rearing of offspring, germination or seed dispersal.

Although critical habitat may be designated on private or State lands, activities on these lands are not restricted unless there is Federal involvement in the activities or direct harm to listed wildlife.

If any species has proposed or designated critical habitat within a quad, there will be a separate line for this on the species list. Boundary descriptions of the critical habitat may be found in the Federal Register. The information is also reprinted in the Code of Federal Regulations (50 CFR 17.95). See our critical habitat page for maps.

Candidate Species

We recommend that you address impacts to candidate species. We put plants and animals on our candidate list when we have enough scientific information to eventually propose them for listing as threatened or endangered. By considering these species early in your planning process you may be able to avoid the problems that could develop if one of these candidates was listed before the end of your project.

Wetlands

If your project will impact wetlands, riparian habitat, or other jurisdictional waters as defined by section 404 of the Clean Water Act and/or section 10 of the Rivers and Harbors Act, you will need to obtain a permit from the U.S. Army Corps of Engineers. Impacts to wetland habitats require site specific mitigation and monitoring. For questions regarding wetlands, please contact Mark Littlefield of this office at (916) 414-6580.

Updates

Our database is constantly updated as species are proposed, listed and delisted. If you address proposed and candidate species in your planning, this should not be a problem. However, we recommend that you get an updated list every 90 days. That would be June 28, 2006.